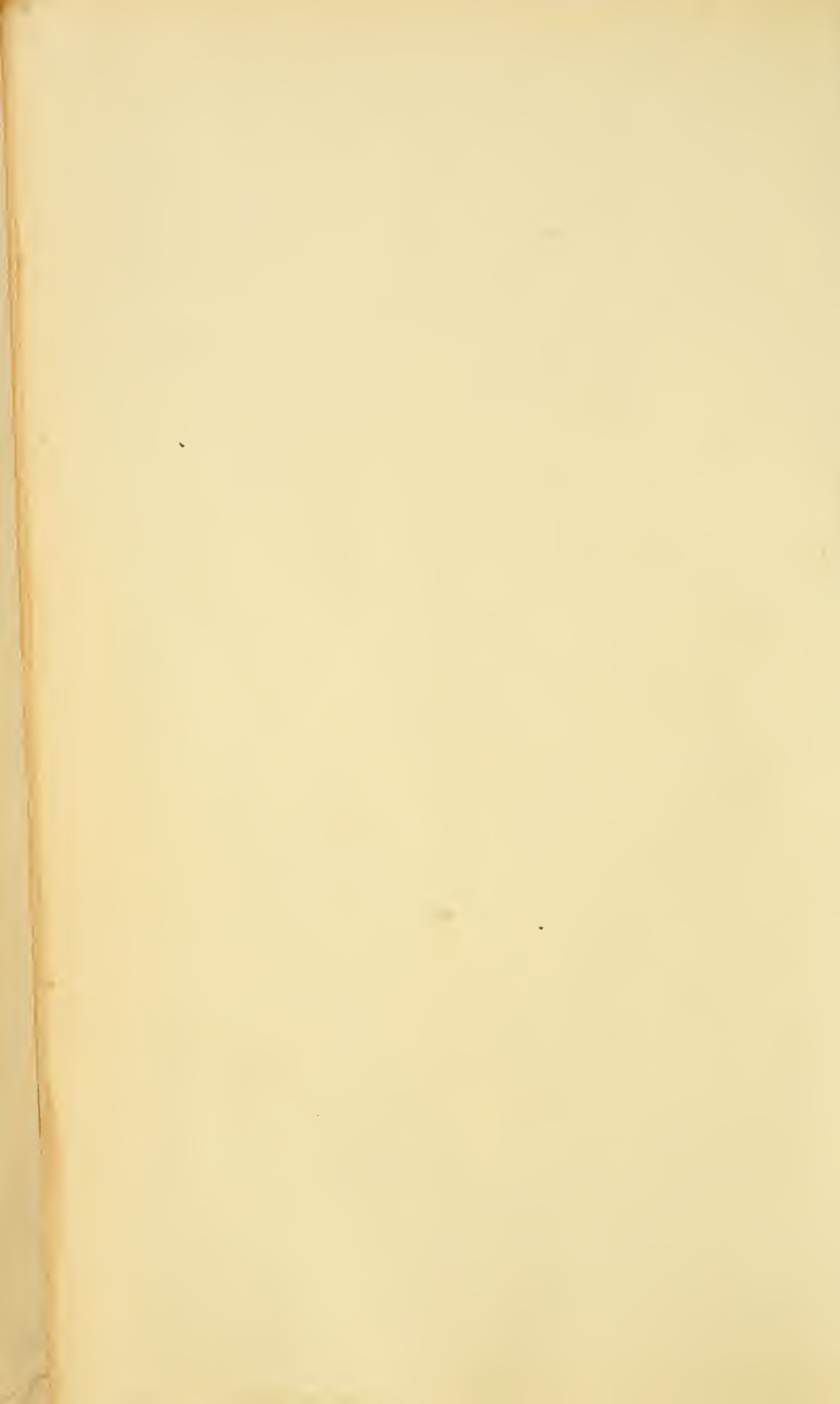


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HANDBOOK OF THE
ECHINODERMS
OF THE
BRITISH ISLES

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OF THE
BRITISH ISLES

BY
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P R E F A C E

AFTER the publication in 1924 of my book on the Echinoderms ("Pighude") in the series *Danmark's Fauna* I was invited to translate it into English, in order that the work might become more generally useful to English zoologists, to whom the language would naturally be a serious hindrance for making full use of the Danish edition of the book. I was very glad to receive the proposal and also felt quite willing to accept it. However, it very soon became evident that a simple translation would not do. The Danish work contains only the species found in the Danish and Scandinavian seas; but there are several species of echinoderms found in the British seas which do not reach the Scandinavian seas, and, therefore, are not included in the Danish work. It was clear that, if a similar book were to be written on the British echinoderms, it must be extended so as to include all the species occurring in the British seas—not the littoral forms alone, but also the rather numerous deep-sea forms known from off the west and north coasts, as they are already included in Bell's *Catalogue of the British Echinoderms* and in several other works dealing with the British echinoderm fauna.

But where to put the limit? To take a certain distance from the coast, *e.g.* 10 miles or more, or a certain depth, *e.g.* the 1000 or 2000 metre line, would be equally arbitrary and contrary to natural conditions. The only reasonable course has seemed to the author to be this: to include the whole of the deep-sea fauna known from off the British coasts down to the greatest depths.

Studying this deep-sea fauna, it was found over and over again that species originally discovered in the Bay of Biscay and off the Azores, and even as far south as Madeira, the Canaries,

and the Cape Verde Islands, have been found to occur also in the British deep-sea area, and inversely. The author was thereby led to the conclusion that the whole of the north-east Atlantic deep sea, from the Azores and the Cape Verde Islands (perhaps even Ascension) in the south to Iceland in the north, forms one single zoogeographical area, and that all the species known from any place within that area may be expected to be distributed all over it, and thus to occur also off the British coasts in suitable depths. Therefore, again, to confine the work only to those species actually known from the British area would mean that in all probability the work would very soon prove to be incomplete, as it is to be expected that any deep-sea dredgings off the west coasts will bring to light species not hitherto found within the British area. The same holds good of the cold area of the Faroe Channel, as it may well be expected that the whole of the fauna characteristic of the deep-sea area of the cold Norwegian sea will prove to extend as far south as the cold, deep water proceeds, thus to within the British area.

The author therefore has thought it desirable to comprise all those deep-sea forms which may reasonably be expected to occur within the British area, though not yet actually known from there—just as in the Danish work all the species which may reasonably be expected to occur, *e.g.* in Skagerrack, though not yet known from there, have been included. While full descriptions and figures are given of all the species known to occur within the British area, the species expected to occur there—though not yet actually found—are less extensively dealt with; only their main characters, necessary for the identification, are given in the keys, usually with reference to the chief works where full descriptions and figures of them are to be found. In this way it is hoped that the book will remain useful also in the future, when many more species shall have been added to the British fauna.

A very striking case, showing the correctness of the course thus adopted, happened, before the manuscript was completed. A small collection of echinoderms from off the Irish coasts, which was sent me by Mr. Farran, proved to contain no less than three genera and species new to the British fauna,

all of which had already been included in the keys as forms expected to occur within the British area, viz., *Odontaster mediterraneus*, *Gastraster margaritaceus*, and *Ophiochondrus armatus*. Furthermore, after the work was completed, some small sea-stars were received from Mr. Farran, among which were two more species new to the British fauna, viz. *Hoplaster spinosus* and *Pedicellaster typicus*. (Cf. Appendix.) These two species also had already been included as likely to occur within the British area.

While the book has thus become much more extensive than the original Danish work, comprising, in fact, the whole of the echinoderm fauna known from the north-east Atlantic, the general plan and scope of the work remain the same—its main object being to offer an easy means of identifying with certainty the various forms of echinoderms known from, or likely to occur in, the British seas, through precise descriptions, keys, and figures, illustrating partly the general appearance of the species, partly the finer details necessary for their determination. Literary references are usually not given under each separate species; anyone wishing to go deeper into the scientific details will find the more important literature quoted in the list of literature given at the end of the book. The author has done his best, without reducing the claims to scientific exactness, to give the work such a form that no special zoological training should be necessary for using it; the index to the unavoidable technical terms, given at the end of the book, may prove useful in this connection. For the same reasons, finer anatomical details have been omitted when not necessary for the determination. It may also be pointed out that in several cases the family diagnoses have been made to fit especially the forms occurring in the north-east Atlantic region, when, namely, if the diagnoses had to fit all the forms belonging to such a family known from the whole world, it would necessitate going too deeply into details difficult to observe and needing a very detailed explanation.

Thus it is hoped that all reasonable claims are fulfilled for making the book useful, not only to zoologists proper, but also to amateurs. The author would, indeed, like to call the attention

of amateurs to this group of animals, which may well compete with shells and insects both in beauty and variety of forms, though certainly not in number of species. The information given as to the best ways of preserving the various forms may also prove useful in this connection.

Besides the diagnoses, brief notes on biology, development, and distribution of the various species are added. It is especially hoped that the descriptions and figures of the pelagic larvæ will prove useful, and make the identification of these larvæ a comparatively easy task.

I beg to offer this work as homage to that great nation which so splendidly opened up the field of science that to me is the most fascinating of all—the biology of the deep sea.

My special thanks are due first to Professor J. Stanley Gardiner, Cambridge, to whom it is especially due that this work was undertaken and carried through; then to Dr. E. J. Allen, Plymouth, who kindly undertook reading proof and correcting the language; further, to Messrs. F. M. Davis, Lowestoft; G. P. Farran, Dublin; C. C. A. Monro, British Museum, London; Dr. J. Ritchie, Edinburgh; and A. W. Stelfox, National Museum, Dublin, for important help with material or literature. Likewise, I beg to thank Miss E. Deichmann, Copenhagen; Drs. Austin H. Clark, Washington, D.C.; Torsten Gislén, Uppsala; James Grieg, Bergen; Hj. Östergren, Gothenburg; H. J. Orton, Plymouth; and Sv. Runnström, Bergen; Professors H. L. Clark, Cambridge, Mass.; W. K. Fisher, Pacific Grove, California; R. Koehler, Lyons; T. Odhner, Stockholm; and J. Richard, Monaco, for most valuable assistance.

TH. MORTENSEN.

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ECHINODERMS

ECHINODERMA

THE Echinoderms are radially symmetrical, mostly five-radiate, marine animals, with a skeleton consisting of calcareous plates and with tube-feet which are in connection with an interior water-vascular system. They never form colonies.

Common to all echinoderms is the radiate structure, as expressed in the arrangement of the tube-feet. The surface of the body is thereby divided into (usually) 10 sections, alternately carrying or devoid of tube-feet. The sections with the tube-feet are termed *Radii* (*Ambulacra*), the other sections *Interradii* (*Interambulacra*). The internal organs also are wholly or partly of radiate structure (watervascular, nerve, and hæmal systems, genital organs); the gut is not radiate in structure.

The *shape of the body* is exceedingly varied. The radii may be free from each other, forming freely movable arms, the body thus becoming star-shaped, as in the Sea-stars (Asteroids) and Brittle-stars (Ophiuroids), or flower-shaped, as in the Sea-lilies (Crinoids), or they may be intimately connected throughout their whole length, the body becoming round, arched, as in the Sea-urchins (Echinoids), or elongate, wormlike, or sausage-shaped, as in the Sea-cucumbers (Holothuriods).

The number of the radii is usually 5; exceptionally 4- or 6-rayed specimens of normally 5-rayed species may occur. Some forms, especially among the sea-stars, are normally pluri-radiate. In most sea-lilies the arms are dichotomous at the base; these thus become 10-armed, or, when the forkings are repeated, many-armed. In some brittle-stars (*Gorgonocephalus*) the arms are branched and tree-shaped.

The *skeleton* (except in the Holothurians) is strongly developed, generally forming a firm coat of regularly arranged plates, which in some forms (especially the brittle-stars) have the shape of vertebræ. In the Holothurians the skeleton is mostly little

developed, consisting of scattered microscopical plates which may be of a very elegant shape. The skin then generally gives the impression of being quite naked. Even in those sea-cucumbers (*Psolus*) which have a more developed skeleton, the plates never show such regular arrangement as in other echinoderms. The skeleton is formed inside the epidermis and is covered with skin, which is mostly finely ciliate.

To the skeleton various structures may be attached, viz. spines, pedicellariæ, and sphæridiæ. The *spines* may reach a considerable size, and are usually articulated to special knobs and provided with muscles, being thus movable in all directions; they are found in sea-urchins, sea-stars, and brittle-stars. The *pedicellariæ* are peculiar organs, often of very complicate structure, sometimes provided with poison glands. Their function is partly to clean the skin of dirt and all kinds of foreign bodies, partly to catch and hold a prey, and partly to serve as defence organs. They are found only in sea-urchins and sea-stars. The *sphæridia*, which are supposed to be organs of taste and smell, or of orientation, are found only in sea-urchins.

The *tube-feet* are cylindrical, highly extensible tubes, generally ending in a sucking disk. Primarily they occur in two series in each radius, but their number may be augmented so as to form four series, or so as to be arranged in arches, or they may be wholly without definite order. In some sea-urchins, and especially sea-cucumbers, they even extend over the interradii, the whole body thus being covered with tube-feet. In sea-stars and sea-lilies they are placed in furrows (ambulacral furrows or grooves) along the arms. The tube-feet mainly serve as locomotor organs. When distended the sucking disk is brought into contact with the substratum; muscles, which are fastened to the middle of the disk, contract, and thus produce a small, empty space. The air or water pressure then attaches the sucking disk so tightly to the substratum that the animal can move itself forwards by shortening the tube-foot. So tightly do they adhere that on catching a specimen thus attached numbers of tube-feet are pulled off, the sucking disks torn off remaining attached to the substratum. The tube-feet are connected with the watervascular system; this system is peculiar to the echinoderms, nothing quite corresponding to it being found in any other group of animals.

The *watervascular system* (Fig. 1) consists of a ring canal, encircling the œsophagus, and five radial canals issuing from it, one for each radius: in the many-rayed forms there is a corresponding number of radial canals. From the radial canals pairs of small

side branches issue, each ending in a tube-foot. At the base of each tube-foot there is generally a small vesicle, the *ampulla*. When this ampulla is compressed, the water (which fills the whole watervascular system) is pressed out into the tube-foot which is thus extended. When the ampulla is relaxed and the muscles of the tube-foot contract, the water flows back from the tube-foot which is thus shortened. A peculiar valvular structure in the ampullæ serves to regulate the filling and emptying of the tube-feet.

On the ring canal are generally found one or more larger

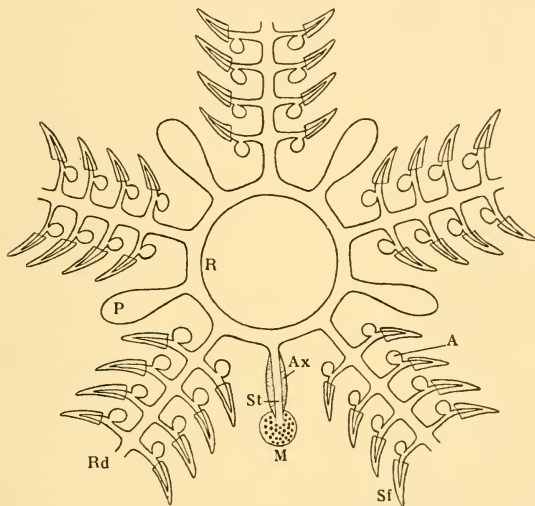


FIG. 1.—Diagram of the watervascular system of a Sea-star.
(From *Danmark's Fauna*.)

A, Ampulla; Ax, Axial organ; M, Madreporite; P, Polian vesicle; R, Ring canal; Rd, Radial canal; Sf, Tube-foot; St, Stone canal.

stalked out-growths, the *Polian vesicles*. Finally, there issues from the ring canal, in one of the interradii (more rarely in all of them), a canal that opens outwards through a larger perforated plate, the *madreporite*; through this canal, the *stone canal*, the watervascular system is filled with water. It is often strongly calcified, to which fact its name is due. Exceptionally (most of the sea-cucumbers) it opens into the body cavity, in which case the fluid that fills the watervascular system is derived from the body cavity.

To the position of stone canal and madreporite in one of the interradii is due the fact that the body is not perfectly radiate, this single interradius thus differing from the other interradii. A section through this interradius and the opposite radius will

divide the body into two symmetrical halves. There is thus in the echinoderms a peculiar combination of a radiate and a bilaterally symmetrical structure.

The same arrangement as is found in the watervascular system is shown by the *nervous system* and the *blood system*: around the œsophagus a ring from which issues a main branch to each radius. The *nervous system* is simple, without ganglia; it lies in sea-stars and sea-lilies in the epidermis, in the other echinoderms inside the epidermis. In addition to this ambulacral nervous system lying in the epidermis, or at least originating from the epidermis, there are in the echinoderms

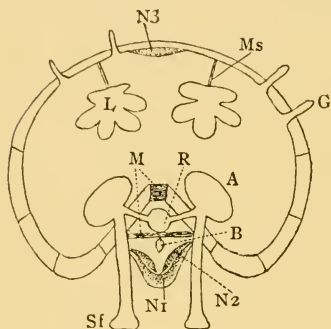


FIG. 2.—Diagrammatic section of an arm of a Sea-star.
(From *Danmark's Fauna*.)

A, Ampulla; B, Radial blood-vessel; G, Gill (papula); L, Liver; M, Muscles; Ms Mesentery; N₁, Ambulacral nervous stem, in the epidermis; N₂, Inner nervous stem; N₃, Dorsal water-vessel; R, Radial water-vessel; Sf, Tube-foot.

two other nervous systems. One of these lies along the inner side of the ambulacral nervous system, following the latter. The other lies on the dorsal side, under the skin. This dorsal nervous system is in the sea-lilies much more developed than the two other systems, while in the other echinoderms it is only slightly developed. The echinoderms thus have no less than three nervous systems.

The *blood vascular* or *hæmal system* follows immediately on the inside of the ambulacral nervous system, lying between the nervous system and the watervascular system. From

the circular vessel that surrounds the œsophagus issue, besides the radial branches, vessels to the intestine and also a vessel which accompanies the stone canal; the latter vessel is in connection with a dorsal or aboral hæmal ring from which branches pass out to the genital organs. There is no heart and no pulsating vessels. In some sea-cucumbers the intestinal vessel forms a rich plexus of blood-vessels, a *rete mirabile*. A well-defined system of lacunæ or "sinuses" surrounds both the circular and the radial vessels and their side branches. Fig. 2 shows the relative position of nervous systems, blood-vessels, and watervascular system.

Kidneys (excretory organs) are lacking; the excretory function is undertaken by *amœboid wandering cells*, which are either

stored up in special places in the body or wander out through the body wall and are thus destroyed. These cells are formed within a glandular organ that accompanies the stone canal, the *axial organ*, or dorsal organ. It was formerly, wrongly, regarded as a heart.

Regarding the arrangement of the *genital organs*, reference must be made to the separate classes. Most echinoderms have separate sexes, but some forms are hermaphrodites. There is usually no external difference between the two sexes. External sexual organs are not found, and no copulation takes place. The sexual products are discharged into the water, where eggs and sperm meet. In those forms which are viviparous internal fertilisation must take place; in such cases the spermatozoa must find the eggs in the place where development is to take place (the body cavity or elsewhere).

The *organs of digestion* consist in the sea-stars and brittle-stars of a large sac-shaped stomach; in the other classes of a long sinuate intestinal canal attached to the body wall by means of a mesentery. All brittle-stars and some sea-stars lack an anal opening, and, accordingly, indigestible matter is discharged through the mouth. In sea-stars a pair of large folded cæca proceed from the stomach into each arm, hanging in a mesentery, and form the *liver*.

The echinoderms pass through a remarkable and very complicated *metamorphosis*. The larvæ are free-swimming (pelagic), and so totally different from the adult animals in structure and appearance that at first they were taken to be separate animals, being described under special names — *Pluteus*, *Bipinnaria*, *Brachiolaria*, *Auricularia* — names which are still partly retained.

The *larvæ* are especially characterised by their vibratile or ciliated band; this band, which is closely set with microscopical hairs (cilia), forms the locomotor organ of the larva. At first it is a simple band surrounding the mouth, but gradually, as the larva grows, it forms folds or armlike outgrowths (processes); these are of constant occurrence and may be homologised in the various larval types. The names of the various processes or arms are seen in Fig. 3.

The four main types of pelagic echinoderm larvæ: *Auricularia* (Holothurian larvæ), *Bipinnaria* (Asteroid larvæ)¹,

¹ The name *Brachiolaria* is sometimes used for a group of Asteroid larvæ which are, in a later stage, provided with special papillate arms and a sucking disk.

Ophiopluteus (Ophiuroid larvæ), and *Echinopluteus*¹ (Echinoid larvæ) may all be derived from the same simple original type. The Crinoid larvæ alone cannot be referred to this type; the few larvæ of sea-lilies known at present are all barrel-shaped, with separate ciliated rings and not a single continuous band. Similar

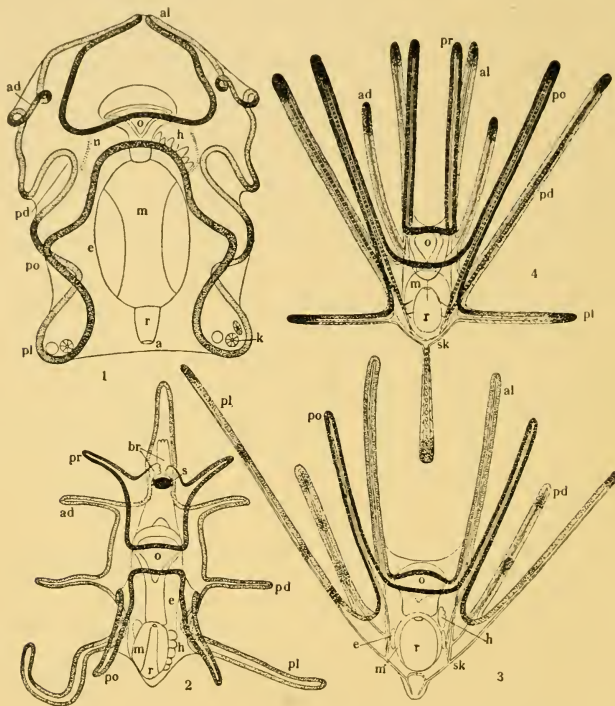


FIG. 3.—The four main types of Echinoderm larvæ.
(From *Danmark's Fauna*.)

1. *Auricularia*, larva of a Holothurian or Sea-cucumber (Synapta). 2. *Bipinnaria* (in the *Brachiolaria* stage), larva of an Asteroid or Sea-star (Asterias). 3. *Ophiopluteus compressus*, larva of an Ophiuroid or Brittle-star. 4. *Echinopluteus*, larva of an Echinoid or Sea-urchin (*Echinocardium cordatum*). (1. After Semon; 2. after A. Agassiz, slightly altered.) A, Anal opening; ad, Anterodorsal arm; al, Anterolateral arm; br, Brachio-larian processes; e, Enterocoel vesicles; h, Rudiment of the watervascular system (the hydrocoel); k, Calcareous wheels; m, Stomach; n, Nervous system; o, Mouth; pd, Posterodorsal; pl, Posterolateral; po, Postoral; pr, Preoral arms; r, Rectum; s, Sucking disk; sk, Skeleton.

larval forms are known also in the other classes, especially in the Dendrochirote Holothurians, which would all appear to have such barrel-shaped larvæ. It probably holds good for all echino-derms with large, yolk-y eggs that they have no true pelagic

¹ The Ophiuroid and Echinoid larvæ were originally designated by the common name *Pluteus*.

larval stage. Some few forms are viviparous or protect their brood; in these, of course, there is no free-swimming larval stage, although the larval form may exceptionally be retained.

The Asteroid larvæ differ from the other echinoderm larvæ, partly by the anterior part of the ciliated band on the ventral (oral) side being separated from the rest of the band, there being thus two separate bands, partly by completely lacking a larval skeleton or other calcareous bodies characteristic of the larva. The Holothurioid larvæ have peculiar calcareous bodies (wheels), the Ophiuroid and Echinoid larvæ have a strongly developed calcareous skeleton, which has nothing to do with the skeleton of the adult but is absorbed during metamorphosis.

The larval mouth lies on the ventral side in a transverse furrow, bordered by the ciliated band. The anterior part of œsophagus is bell-shaped and wide; the stomach is rather large, globular; the rectum generally bends towards the ventral side, where the anal opening lies. At the sides of the stomach lie two pairs of small vesicles, the anterior and posterior *enterocoel vesicles*. From the left anterior vesicle a canal—the stone canal—arises, which opens to the exterior on the dorsal side through a pore—the dorsal pore; around this pore the madreporite is formed. From this enterocoel vesicle also the watervascular system (*hydrocoel*) develops, at first in the shape of five blunt outgrowths lying crescentically at the side of the œsophagus; gradually it forms a closed ring around the œsophagus, the ring canal, the five outgrowths forming the radial canals. Various modifications of this arrangement are met with, but they may all be traced back to this simple original type of development.

The echinoderm larvæ are generally small, microscopical animals, only a few, like the *Luidia* larva, the tropical *Auricularia nudibranchiata* and the antarctic *Auricularia antarctica*, reaching a more considerable size, up to 35 mm. in length. They are quite transparent, at most with some pigment spots, chiefly at the ends of the arms, and are among the most beautiful microscopical objects.

Key to the main types of pelagic Echinoderm Larvæ.

1. No skeleton, at most isolated calcareous bodies 2
 Skeleton present 3
2. Anterior part of ciliated band not separated from the rest of the
 band; calcareous bodies (wheels, stars) usually present
 Holothurian larvæ, *Auricularia*

Anterior part of ciliated band separated from the rest; no calcareous bodies Asteroid larvæ, *Bipinnaria*

3. Skeleton consisting of two symmetrical halves; posterolateral arms directed forwards, strongly developed

Ophiuroid larvæ, *Ophiopluteus*

Skeleton consisting in I. stage of two, in II. stage of four paired and one or two unpaired parts; posterolateral arms wanting or directed backwards or to the side

Echinoid larvæ, *Echinopluteus*

In addition to sexual reproduction several echinoderms have another way of propagating, viz. by self-division, each half regenerating the lacking part and thus developing into a complete individual. Among British species this appears to be normally the case in *Cucumaria lactea*, as it is in the Mediterranean species *Ophiactis virens* and *Coscinasterias tenuispinus* and two species from the Scandinavian seas, *Ophiactis nidarosiensis* and *Psolus valvatus*. By such division the two parts are always completely severed from each other; colony formation is unknown among echinoderms.

This peculiar mode of propagation has some relation to the fact that *regenerating power* is, on the whole, very strong in echinoderms. Sea-stars and brittle-stars with regenerating arms are very commonly met with. Some brittle-stars (especially *Amphiura filiformis* among British species) may throw off the disk (with the stomach and the genital organs) and regenerate it all. The same holds good of the sea-lilies. Most sea-cucumbers may, by strongly contracting the body wall, eject the whole of their internal organs through the anal opening, and regenerate all again.

The echinoderms occur in all depths of the sea, from the shore to several thousand metres. They are very sensitive to brackish water, which accounts for the fact that the whole of the eastern Baltic is quite devoid of echinoderms. No echinoderm is found in fresh water. Some species occur in such great numbers as to be among the main characteristics of various animal communities of the sea (e.g. *Echinocardium cordatum*, *Amphiura filiformis*, *Ophiura affinis*). Upon the whole, the echinoderms play an important rôle in the economy of the sea, partly because they devour great quantities of other animals, mussels, snails, worms, etc., partly through serving as food to various species of fish, e.g. cod, haddock, plaice, dab. Also some sea-birds, mainly in the Arctic regions, eat echinoderms, especially the sea-urchin *Strongylocentrotus dröbachiensis*. In more southern regions some species of sea-urchins are highly esteemed as food for man (only the genital organs are eaten).

In the Indo-Pacific regions several species of sea-cucumbers are eaten, mainly by the Chinese ; only the skin is used, dried and smoked ("bêche de mer," "trepang").

Most echinoderms lend themselves excellently for preservation in a dried state ; they ought, however, first to lie in alcohol or formalin for a few days. Formalin ought not to be used for preserving echinoderms for any longer time, because, if not neutralised, it dissolves the calcareous structures ; it is, however, excellent for preserving sea-stars, in so far as it keeps the colour fairly well, which is always lost on using alcohol. If then sea-stars are dried after having been preserved some days in formalin they may keep their colour fairly well (though not all species). Sea-cucumbers should always be preserved in alcohol.

On account of the strongly developed calcareous skeleton the echinoderms are among the commonest of *fossils*, especially sea-lilies and sea-urchins. They occur in all formations, from the oldest fossiliferous deposits to the most recent geological formations. During the glacial epoch numerous such fossils (especially sea-urchins of the genera *Echinocorys* (*Ananchytes*) and *Conulus*) from the Cretaceous formation were scattered all over the countries of northern Europe, carried along by the ice. Such earth-found specimens have played a great part in folk-lore ; they were regarded as thunder-stones, fallen from heaven with the thunder, and supposed therefore to protect against the thunder. They were also used in prehistoric times as amulets.

The echinoderms are generally divided in two main groups : the *Stalked Echinoderms* or *Pelmatozoa* (sea-lilies and their fossil relatives, the Cystidea and the Blastoidea) and the *Free-living Echinoderms* or *Eleutherozoa* (sea-stars, brittle-stars, sea-urchins, and sea-cucumbers). A more recent classification distinguishes three main groups : Pelmatozoa (sea-lilies, etc.), Asterozoa (sea-stars and brittle-stars), and Echinozoa (sea-urchins and sea-cucumbers). None of these classifications, apparently, represents quite correctly the mutual relationship of the classes. It would seem more probable that sea-stars and brittle-stars are closely related and form one natural group, with which again the sea-urchins are, somewhat more distantly, connected, whereas sea-cucumbers and sea-lilies are not very closely related with this group or with each other.

Key to the Classes of recent Echinoderms.

1. Attached by means of a stalk, at least in the younger stages.
 Arms feather-shaped *Sea-lilies* or *Crinoids* (*Crinoidea*)
 Free-living, no stalk. Arms not feather-formed, or wanting 2

2. A strongly developed, regularly arranged calcareous skeleton present ; body star-shaped, globular or egg-shaped . . . 3
No strong, regularly arranged skeleton, at most imbricating scales, and in this case with a naked, flat ventral disk. Body sausage-shaped *Sea-cucumbers* or *Holothurians* (*Holothurioidea*)
3. Body star-shaped, usually with distinct arms 4
Body globular or egg-shaped or flat ; no arms
Sea-urchins or *Echinoids* (*Echinoidea*).
4. Arms long and slender, sometimes branching, sharply marked off from the disk. Tube-feet not in an open groove on the ventral side of the arms
Brittle-stars or *Ophiuroids* (*Ophiuroidea*)
Arms not sharply marked off from the disk, never branching.
Tube-feet in an open groove on the ventral side of the arms
Sea-stars or *Asteroids* (*Asteroidea*)

I. CLASS. SEA-LILIES OR CRINOIDS

(CRINOIDEA)

Cup-shaped echinoderms with feather-like arms ; attached, constantly or only in the young stage, by means of an articulated stalk, arising from the dorsal side of the body. A long, coiled intestinal canal ; stomach not sac-shaped. Mouth and anal openings on the ventral side, which is turned upwards. Ambulacral grooves open.¹

The *stalk* of the sea-lilies known to occur in the British seas is thin and slender, with root-like, branching appendages. In other forms (family Isocrinidæ) it is very stout, pentagonal, with articulate, unbranched appendages, *cirri*, arranged in whorls. In feather-stars (Comatulids) cirri occur only on the uppermost stalk-segment, which is strongly developed, and is termed the *centro-dorsal*. The cirri are attached, each in a small groove, the *cirrus-socket*, on the centro-dorsal. The shape and arrangement of these sockets is of systematic importance, as the centro-dorsal usually, through its great variation in regard to shape and size, affords characters of much systematic value within the Comatulids. This also holds good for the cirri, which show

¹ In literature on Echinoderms the designations "*actinal*" and "*abactinal*" are very commonly used for "*ventral*" and "*dorsal*", as also the term "*actinostome*" for the mouth. The author does not see any necessity at all for using these artificial terms, and therefore uses the simple, unmistakable designations "*ventral*" and "*dorsal*", or "*oral*" and "*aboral*".

great variation in regard to size, number and shape of the joints or segments. The last cirrus-segment is transformed into a hook or claw, and the penultimate segment is very often produced on its distal, dorsal edge into a smaller spine, the opposing spine. In many forms the distal segments have the distal, dorsal edge produced into a small spine (*e.g.* Fig. 12, 1). As a rule the cirri curve more or less downwards, in accordance with their function as a means of attachment. It may be pointed out that the concave side of the cirrus is the dorsal side. In descriptions of the Comatulids the number of the cirri is given in Roman, the number of the cirrus segments in Arabic figures.

The *body* has the shape of a cup, the *calyx*, the outer, or dorsal, side of which is formed by strong, regularly arranged plates. These plates are of great importance for the classification of sea-lilies. Their special designations are given when dealing with their development.

Along the dorsal side of the *arms* there is a series of strong, calcareous joints, the *brachials*, resembling a vertebral column; they are connected with one another by means of ligaments and strong muscles. At regular intervals joints occur which are connected by ligaments alone; such joints, which are termed *syzygies*,¹ are easily distinguished, as they are separated only by a faint transverse furrow, while the other joints are separated by a broader furrow, in which the dorsal ligament is seen.

The number of the arms is originally five; in most sea-lilies, however, the arms bifurcate at the second joint, the *axillary*, which has two oblique articular surfaces on its outer, distal end. In numerous, mainly tropical forms the arms bifurcate again farther out, once or several times, so that the number of arms may be very large. Along the arms are found side branches, *pinnules*, which arise alternately from each side and are articulated to the outer edge of the arm joints. Each arm joint thus, as a rule, carries a pinnule, excepting the lower joint in a syzygial pair. Like the arms, the pinnules have along the dorsal side a series of calcareous ossicles, only much thinner and more slender than those of the arm; the outer (distal) joints are often rather strongly spiny. The lowermost pinnules are usually more or

¹ There are, in reality, two kinds of non-muscular articulation of the arm-joints, *synarthry* and *syzygy*. There is, however, no necessity for going into such details here, as they are of no material importance for the identification of the Crinoids known from, or to be expected to occur in, the British seas. Likewise, several other technical details unnecessary for the identification of the N.-E. Atlantic Crinoids are omitted.

less modified, long, whip-like, stiffened or combed, and are termed *oral pinnules*. These latter especially are of great systematic value owing to the great variation in the number and shape of their joints. In the systematic descriptions the pinnules are designated P_1 , P_2 , P_3 , etc.

The *ambulacral grooves* proceed from a ring around the mouth and form a conspicuous five-rayed star on the ventral side of the body (the disk). At the edge of the disk each groove bifurcates; one branch goes to each arm, along its ventral side, usually to the very tip, sending off a side branch to each pinnule. In the grooves the *tube-feet* or *tentacles* are found, arranged in a series along each side of the groove. It is characteristic of the sea-lilies, contrary to all other echinoderms, that the tube-feet are arranged in groups of three. They are set with sensory papillæ, but have no sucking disk; they have not the function of locomotor organs. Along the ambulacral grooves there are some small plates, the *side* and *covering plates*, which, in the Comatulids, are generally reduced to small, microscopical spicules, while in the stalked forms they are mostly well developed.

On each side of the ambulacral groove lies a series of small bodies about the size of a pin-head, the *sacculi*, the function of which is not yet quite settled. Probably they have something to do with excretion (they have been regarded as parasitic organisms). They are colourless in life, but in preserved Comatulids are generally very conspicuous; in many forms they secrete a colouring matter that colours alcohol intensely red. In the stalked Crinoids (*e.g.* in *Rhizocrinus*) they are often of a yellowish colour and difficult to observe.

The *mouth* usually lies in the middle of the disk and the anal opening about midway between the mouth and the edge of the disk, generally on a high conical process, the *anal cone*. In many forms (of the family Comasteridæ), however, the anal cone is situated in the centre of the disk, the mouth, with the surrounding ambulacral grooves, being pushed out towards the margin. The intestinal canal makes one or (in the Comasteridæ) more dextral coils; it is generally provided with some sac-shaped outgrowths which possibly have the function of a liver.

There is no madreporite; instead, there are in each interradius a number of small pores, the *hydropores* or *calyx pores*, which lead into the body cavity, into which open also the numerous small stone canals that issue from the ring canal. *Rhizocrinus* has only one hydropore and one stone canal in each interradius; in *Antedon* there are several hundreds of them.

The ambulacral *nervous system* is only feebly developed and not separated from the epidermis. On the other hand, the dorsal or aboral nervous system is strongly developed. Within the centro-dorsal it forms a conspicuous central organ, like a brain, from which there radiates to each arm a branch, situated in a canal in the centre of the calcareous joints, like the spinal canal of a vertebral column. Also the nerves to the stalk and the cirri arise from the central organ in the centro-dorsal.

The *genital organs* are generally situated in the pinnules. When the eggs are shed they remain in some forms (*e.g. Antedon bifida*) in small clusters round the genital opening on the side of the pinnule, and here pass through the first developmental stages; only when the larva has acquired its full shape does it rupture the egg membrane and become free. In others (*e.g. Antedon petasus*) the eggs are free; in this case the embryo is uniformly ciliated when it ruptures the egg membrane and only later acquires the ciliated rings characteristic of Crinoid larvæ. The *larva* has no mouth and so cannot take food, but subsists upon the yolk contents of the egg. Within the larva the skeleton of the sea-lily is formed, so orientated that the stalk lies in the anterior end, the calyx in the posterior end of the larva. Thus the anterior end of the larva becomes the posterior end (the stalk) of the sea-lily, while the posterior end of the larva becomes the anterior end of the sea-lily, the mouth appearing there. After swimming for some time, at most some few days, the larva attaches itself, with its anterior end, to some foreign object, an alga, a hydroid, or the like. After some remarkable internal transformations the calyx opens, the first tentacles protrude, and the young sea-lily begins to feed.

The *skeleton of the calyx* is at first formed as two whorls of beautiful fenestrated calcareous plates, five in each whorl;¹ they are designated *basals* (lower whorl) and *orals* (upper whorl); the latter form five valves around the mouth. Soon a new whorl of plates, the *radials*, appears, situated in the interstices between the first two whorls, and thereafter, above the radials, the first two ossicles of the arms, the *brachials*₁₋₂; the second brachial becomes the *axillary*, from which the arm bifurcates;

¹ Generally a third whorl of very small plates develops below the basals, alternating with these; they are termed *infrabasals*. On account of their small size and their being partly covered by the basals, they are not easily observable, and their existence in the common British species *Antedon bifida* has generally been denied. In reality they are well developed there. As a rule the infrabasals are only three in number, two of them being somewhat larger, each representing two fused plates.

it has two articulating surfaces at its distal end, from each of which a series of plates arise, which develop into the arm-joints. Close to one of the radials lies a small plate, the *anal plate*, which later on disappears in most recent forms. With the growth of the radials the orals and basals are gradually separated from each other. The orals remain at the mouth-edge and ultimately disappear in most Comatulids. The basals undergo a remarkable metamorphosis ; gradually they disappear from the surface of the calyx and are transformed within the calyx into a small plate, the rosette, which lies as a cover over the cavity of the centro-



FIG. 4.—Sketch of swimming Feather - star (*Antedon bifida*). Nat. size.
(From H. C. Chadwick.)

dorsal. This latter is formed by the uppermost stalk joint, which grows very wide and gradually conceals the radials. On the centro-dorsal the *cirri* develop ; when a couple of whorls of *cirri* has appeared, the young sea-lily detaches itself from the stalk and then attaches itself to the sea-bottom by means of the *cirri*, while the stalk falls to pieces. The fixed stage of the Comatulids is designated the *Pentacrinoid stage* (cf. Figs. 16, 17, 19, 25). The development of the stalked Crinoids is unknown.

The Comatulids, as a rule, live attached, by means of their *cirri*, to the sea-bottom, or to other organisms, moving their arms only feebly ; but they are able to relax their hold and swim freely, moving their arms alternately up and down (Fig. 4). Such

swimming feather-stars afford an exceedingly beautiful sight ; the feather-stars, with their often very vivid colours, are, indeed, among the most beautiful of marine animals. Among fossil Crinoids a few forms are known which have led a perfectly free, pelagic life ; no such forms are known to exist in recent times. The *food* of the sea-lilies consists mainly of plankton organisms, which are caught by means of the tentacles and carried to the mouth by the cilia in the ambulacral grooves, which send a constant current of water towards the mouth. Probably also the oral pinnules, in some cases, help directly in catching the food. Besides plankton organisms, detritus also appears to form an important part of the food of sea-lilies. No other animals are

known to feed regularly on Crinoids. The regenerating power of sea-lilies is exceedingly great. On being hurt, or on being kept under unfavourable conditions, they throw off not only the arms but often also the whole disk, with mouth, intestinal canal, etc., and easily regenerate it all again.

On the sea-lilies there is almost constantly found a remarkable parasitic animal, *Myzostoma* (Fig. 5), a sort of peculiarly transformed Chætopod, with a rather long, protrusile proboscis. Generally it creeps freely along on the disk and arms, moving rather swiftly; some species form a sort of gall or cyst, in which they live.

Sea-lilies were much more numerous represented in former geological epochs than they are in recent time, excepting only the Comatulids. Fossil remains of sea-lilies are therefore exceedingly numerous, and are of the highest importance, both from a geological and a zoological point of view. While the stalked Crinoids are very often found in a perfect state of preservation, usually only the centro-dorsal and more rarely a few of the first brachials are found of fossil Comatulids.

Four families of Crinoids are represented in British seas; possibly, however, four more will ultimately prove to occur in the deep sea off Ireland, viz. the family *Isoocrinidae*, one genus and species of which, *Annacrinus Wyville-Thomsoni* (Jeffreys), (syn. *Pentacrinus Wyville-Thomsoni* Jeffreys), is known from the Bay of Biscay, southward to the Canaries, ca. 1330-2000 m. ("Porcupine", "Talisman", "Princesse Alice"); the family *Hyoocrinidae*,¹ with the one genus and species *Gephyrocrinus Grimaldii* Koehler and Bather, known from off Madeira and the Canary Islands to the equatorial mid-Atlantic, 1786-3382 m. ("Princesse Alice"); the family *Thalassometridae*, three genera of which are represented in the N.-E. Atlantic (cf. below, p. 25), and the family *Comasteridae*, one genus and species of which, *Neocomatella europæa* A. H. Clark, has been found from off Brittany (48° 07' N.) to S. of the Canary Islands, 400-1710 m. ("Porcupine"). These four families are included in the following key:

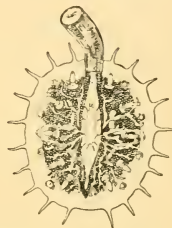


FIG. 5. — *Myzostoma cirriferum* Leuckart, parasite of *Antedon petasus*; with proboscis protruded. $\times 7$. (After Lovén; from *Danmark's Fauna*.)

¹ A. H. Clark ("Ingolf" Crinoidea) regards *Gephyrocrinus* and some other recent Crinoids (*Hyoocrinus*, *Ptilocrinus*) not known from the Atlantic as belonging to the family *Plicatocrinidae*.

Key to the families of Crinoids known from or likely to be represented in the British seas.

1. Stalked ; upper joint of stalk not widened so as to form a centro-dorsal ; calyx externally visible 2
 No stalk, except in the young (Pentacrinoid) stage ; upper stalk-joint widened so as to form a centro-dorsal, which covers the calyx-plates more or less completely. Articulate cirri on the centro-dorsal, or on the upper stalk-joint in the Pentacrinoid-stage. (*Comatulids*) 4
2. Whorls of true, articulate cirri (5 in each whorl) at regular intervals on the stalk Fam. *Isocrinidæ*
 No true, articulate cirri, only rootlike, branching appendages may be present in the lower part of the stalk 3
3. Stalk-joints short, with circular articular faces ; no root-like appendages ; ventral side of disk distinctly plated ; large orals Fam. *Hyocrinidæ*
 Stalk-joints, except immediately below the calyx, much longer than broad, with elliptical articular faces, root-like appendages present in basal part of stalk ; ventral side of disk unplated ; no orals I. Fam. *Bathyrinidæ*
4. Cirrus-sockets bordered above and on the sides by a horseshoe-shaped rim ; centro-dorsal elongate, conical
 II. Fam. *Atlecrinidæ*
 Cirrus-sockets not bordered by a horseshoe-shaped rim 5
5. Arms undivided (five in the British forms)
 III. Fam. *Pentametrocrinidæ*
 Arms divided on the second brachial 6
6. Oral pinnules with the outer edge of each of the distal joints produced into a thin, rounded, triangular process, forming a conspicuous comb-like structure. Mouth usually excentric, anal tube central. No sacculi Fam. *Comasteridæ*
 No comb-like structure on the oral pinnules ; mouth central, anal tube marginal ; sacculi present 7
7. Pinnules stiffened, prismatic, sharply triangular in cross-section ; oral pinnules only feebly specialised ; ambulacral grooves on pinnules and arms bordered by two rows of minute but distinct plates. Cirri long, the distal joints with a prominent dorsal spine ; cirrus-sockets arranged in 10 columns
 Fam. *Thalassometridæ*
 Pinnules not stiffened, not prismatic ; oral pinnules very specialised ; no, or only microscopical, plates along the ambulacral grooves IV. Fam. *Antedonidæ*

I. Family BATHYCRINIDÆ

(Syn. *Bourgueticrinidæ* auct.)

Stalk slender, consisting of elongate joints with elliptical articular surfaces, those of the two ends of each joint at an angle to each other. The upper stalk-joint not specially developed, new joints constantly forming under the calyx. No true cirri, only root-like, branching appendages in the basal part of the stalk.

The sea-lilies of this family are very liable to throw off their arms; specimens with the arms regenerating are therefore often met with.

Two genera of this family are known from the British seas. It is, however, very probable that three (four) more genera will ultimately be found to occur there, namely—besides *Ilycrinus* Dan. and Kor. (see below, p. 20)—*Bathycrinus* Wyv. Thomson, the species *B. gracilis* Wyv. Thomson being known from off the Bay of Biscay, 4450 m. ("Poreupine"); *Monachocrinus* A. H. Clark, with three N.E. Atlantic species (cf. below, p. 21), and *Bythocrinus* Döderlein,¹ the species *B. robustus* (A. H. Clark), being known from off the coast of Portugal, the Josephine Bank, and the West Indies, ca. 160-1745 m. These genera are therefore included in the following key:

Key to the genera of Bathycrinidæ known from or likely to occur in the British seas.

1. Muscular and non-muscular (ligamentous) articulations alternating regularly throughout the arm (Fig. 6, 1). 5-10 (4-12) arms 2
5th, 8th and 11th joints, counted from the radials, have a muscular articulation at either end (Fig. 6, 2). 10 arms . . . 5
2. 10-12 arms, each radial bearing two arms *Monachocrinus* A. H. Cl.
5 (4-7) arms, each radial bearing only one arm . . . 3
3. Basals fused into a solid conical ossicle; no sutures between the basals (Fig. 6, 1). 4-7 arms . . . 1. *Rhizocrinus* M. Sars
Basals separated by distinct sutures (Fig. 6, 2). 5 arms . . . 4
4. Stalk relatively slender, longest joints at least twice as long as broad; calyx more or less conical . . . *Bythocrinus* Döderlein
Stalk rather stout, the longest joints usually only slightly longer than broad, rarely so much as twice as long as broad. Calyx almost or quite cylindrical . . . 2. *Democrinus* Perrier

¹ The genus *Bythocrinus* should perhaps rather be united with *Democrinus*.

5. Distal edges of arm-joints produced, overlapping the bases of the succeeding joints, the dorsal profile of the arm thus being serrate. Axillary markedly broader than long, distinctly shorter than the preceding joint . . . *Bathycrinus* Wyv. Th.
 Distal edges of arm-joints not produced, dorsal profile of arm smooth; axillary scarcely broader than long, about as long as the preceding joint *Ilycrinus* Dan. and Kor.

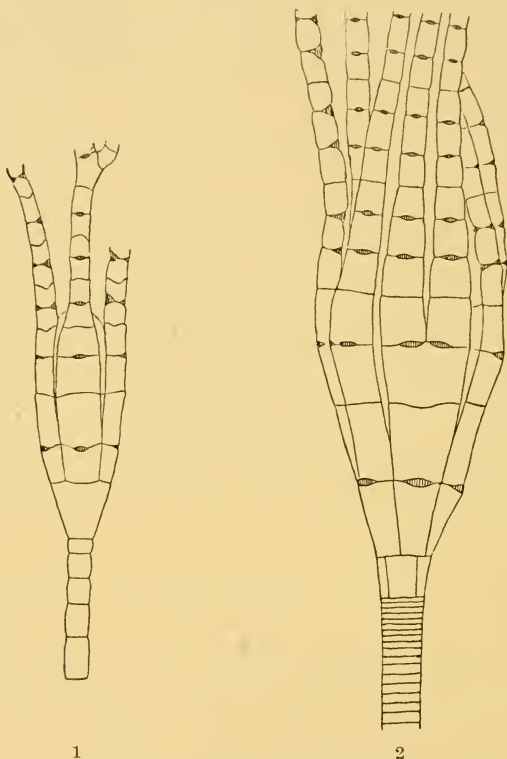


FIG. 6.—Calyx, basal part of arms and upper end of stalk of *Rhizocrinus lofotensis* (1) and *Ilycrinus Carpenteri* (2). $\times 9$.

1. *Rhizocrinus* M. Sars.

Basals distinctly higher than the radials, completely fused into a solid conical, cup-shaped ossicle, without sutures (Fig. 6, 1); also the radials partly coalesced with the basal cup. Muscular and non-muscular (ligamentous) articulations alternating regularly throughout the arm. 4-7 arms.

Only one species in British (and European) seas.

1. *Rhizocrinus lofotensis* M. Sars. (Fig. 7.)

Stalk slender, up to ca. 70 mm. long, with up to ca. 65 joints, the longest of which, in the middle of the stalk, are ca. 1.5 mm. long, 2-3 times as long as broad. The lower part of the stalk usually irregularly bent, lying on the bottom, to which it is anchored by means of the root-like branching appendages. Arms short, ca. 10 mm. long, with ca. 5-6 pinnules on each side. Large side-plates along the ambulacral grooves. Calyx and arms greyish or beautifully yellow in the living specimens.

Specimens with 4, 6, or 7 arms are commonly met with.

This species appears to be rather uncommon in the British seas, since it has only been recorded from the Faroe Channel (59° 36' N., 7° 20' W., 954 m.; "Porcupine") and from 53° 58' N., 12° 24' W., 687 m. ("Helga"). Elsewhere it is widely distributed, occurring in the European seas from off Lofoten, on the Norwegian coast, and off south Iceland to the Bay of Biscay. Also on the American side of the Atlantic it is known, occurring from off Florida to Davis Strait. Its bathymetrical distribution is from 140 down to ca. 3000 metres.

The form occurring off the American coast has been regarded as a separate species, *Rhizocrinus Verrilli* A. H. Clark; this has, however, again been withdrawn by its author as being a variety only of *Rh. lofotensis*.

2. *Democrinus* Perrier.

Basals distinctly higher than radials, forming a more or less cylindrical calyx, not completely fused, but separated by usually rather distinct sutures. Radials free, not coalesced with the basals. Muscular and non-muscular (ligamentous) articulations regularly alternating throughout the arms. Five simple, undivided arms.

One species in British (and European) seas.

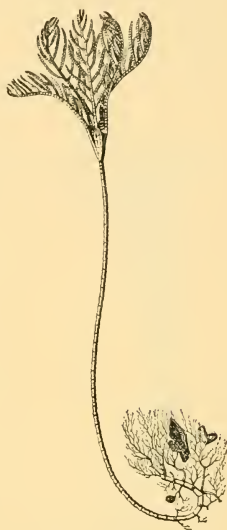


FIG. 7.—*Rhizocrinus lofotensis*. About natural size. (After Wyv. Thomson; from *Danmark's Fauna*.)

1. *Democrinus Parfaiti* Perrier. (Fig. 8.)(Syn. *Rhizocrinus Rawsoni* auct., non Pourtalès.)

A rather robust species, the stalk attaining a length of ca. 160 mm., the calyx of 9 mm. First brachial a little longer than the second.



FIG. 8.—Calyx, basal part of arms and upper stalk-joints of *Democrinus Parfaiti*. (After Perrier.) $\times 2$.

This species has never been adequately described, because it has been regarded as identical with the American species *D. Rawsoni* Pourtalès until recently A. H. Clark pointed out its distinctness. No material being available to the author, such description cannot be given here either. In general appearance the species must evidently be very much like *D. Rawsoni*, as represented in the beautiful figure Plate IX.₃ of P. H. Carpenter's report of the stalked Crinoids of the "Challenger." It has been thought desirable to reproduce here the not easily accessible figure given by Perrier (*Explorations sous-marines*) of the type specimen of *D. Parfaiti*. The essential difference between the two species would appear to be in the shape of the calyx, which is more cylindrical in *Rawsoni*.

In British seas *D. Parfaiti* was found at 50° 1' N., 12° 26' W., 2162 m. and 1540 m. ("Porcupine"). It is known elsewhere as far south as the Azores and the Canaries; the bathymetrical distribution is 1425-4255 m.

[*Ilycrinus* Danielssen and Koren.]

Of this genus, the characters of which are given in the key, only one species, *Ilycrinus Carpenteri* Dan. and Kor., is found in European seas, where it is restricted to the cold Arctic Sea between Greenland, Iceland, and Norway; it has been found as far south as 63° 13' N., 6° 32' W. ("Michael Sars"), and there is every probability that it will occur as far south as the deep cold area extends, thus also into the British area. It has therefore been thought desirable to include a figure of this fine Crinoid (Fig. 9). It is a fairly large form, reaching a length of the stalk

of ca. 270 mm. and an arm length of ca. 30 mm. Its bathymetrical distribution is ca. 1350-2800 m.

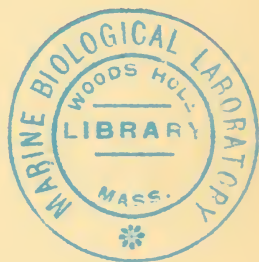
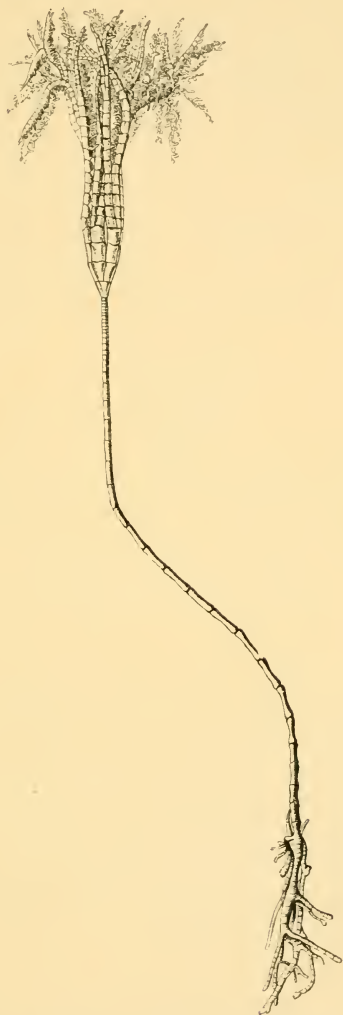


FIG. 9.—*Ilycrinus Carpenteri*. About natural size. (After Danielssen.)

[**Monachocrinus** A. H. Clark.]

Of this genus (characters, see key) three species are known from the N.E. Atlantic, and may be expected to occur also in the British seas. These are : *Monachocrinus sexradiatus* A. H. Clark,

S.W. of Iceland ($61^{\circ} 44' N.$, $30^{\circ} 29' W.$, 2075 m., "Ingolf"); *M. recuperatus* (Perrier) (Syn. *Bathycrinus*, *Ilycrinus recuperatus* Perr.), between Azores and Spain ("Talisman"), and $35^{\circ} 36' N.$, $8^{\circ} 23' W.$ ("Michael Sars"), 2300-4255 m.; *M. Perrieri* (Koehler and Vaney) (Syn. *Bathycrinus Perrieri* Koehler and Vaney), $30^{\circ} 3' N.$, $14^{\circ} 2' W.$, 2212 m. ("Talisman"). These three species are thus distinguished:

- | | | | | | | | | | | |
|----|------------|---------|---|---|---|---|---|---|---|-----------------------------------|
| 1. | 6 radials. | 12 arms | . | . | . | . | . | . | . | <i>M. sexradiatus</i> A. H. Clark |
| | 5 „ | 10 „ | . | . | . | . | . | . | . | 2 |
2. Basals fused into a solid ring, showing no sutures
M. Perrieri (Koehler and Vaney)
 Basals not fused together, sutures between them distinct
M. recuperatus (Perrier)

II. Family ATELECRINIDÆ

Free, unstalked Crinoids, with a long, conical centro-dorsal, with cirrus-sockets arranged in (usually) ten equidistant columns, each socket bordered above and on the sides by a horseshoe-shaped raised rim. Arms 5 or 10 in number.

Only one genus known in the British seas (and the whole Atlantic).

1. *Atelecrinus* P. H. Carpenter.

Arms dividing on second post-radial joint, 10 in number. No pinnules on the lower 10-12 arm-joints. Basals more or less distinctly visible above the upper edge of the centro-dorsal.

The species of this genus are exceedingly brittle, and nearly always come up entirely broken, with only the basal part of the arms preserved and most of the cirri lost. All are deep-sea forms.

Only one species in British seas.

1. *Atelecrinus helgæ* A. H. Clark. (Fig. 10.)

Cirrus-sockets arranged in two fairly regular, very closely crowded columns in each radius, 3-4 to each column. Basals very short, distinct only between the radials; the part below the radials is hidden or reduced to a mere line separating the latter from the centro-dorsal; radials short, 4-5 times as broad as long in the median line.

Only found twice, namely, $53^{\circ} 58' N.$, $12^{\circ} 24' W.$, 699 m. ("Helga"), and $61^{\circ} 15' N.$, $9^{\circ} 35' W.$, 900 m. ("Thor").

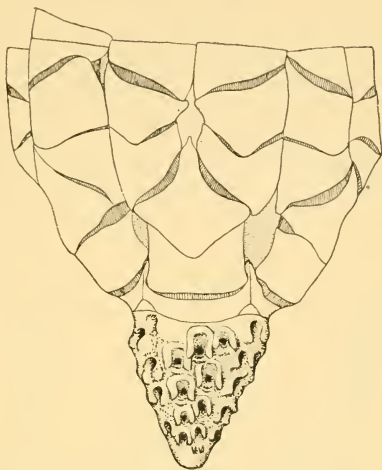


FIG. 10.—*Atelecrinus helga*; dorso-central, calyx, and basal part of arms.
× 6.

III. Family PENTAMETROCRINIDÆ

Free, unstalked Crinoids. Cirrus-sockets not bordered by a horseshoe-shaped raised rim. Basals hidden. Arms undivided, 5 or 10; when there are 10 arms (*Thaumatocrinus*) there are also 10 radials, the arms also in this case being undivided.

Two genera represented in the N.E. Atlantic. Only one of these, *Pentametrocrinus* A. H. Clark, is known from the British seas, but very probably also the second, *Thaumatocrinus* P. H. Carpenter, will be found there, viz. the species *Th. Jungerseni* A. H. Clark, known from W. and S.W. of Iceland, 823-2075 m. ("Ingolf"), a small form, with ix-xvii, rarely more than xiv, long and slender cirri (cf. A. H. Clark, "Ingolf" Crinoidea, p. 13).

Key to the genera of Pentametrocrinidæ known from or likely to be represented in the British seas.

5 radials and 5 undivided arms	.	1. <i>Pentametrocrinus</i> A. H. Cl.
10 „ „ 10 „ „	.	<i>Thaumatocrinus</i> P. H. Carp.

1. *Pentametrocrinus* A. H. Clark.

Five radials and 5 undivided arms. Disk large, extending far up on the arms. Centro-dorsal low, cirrus-sockets not arranged

in regular columns. Cirri without opposing spine, but with a long terminal claw.

One species known from the British seas (and the Atlantic).

1. *Pentametrocrinus atlanticus* (Perrier). (Fig. 11.)

(Syn. *Eudiocrinus atlanticus* Perrier.)

Cirri slender, xx-xxv, with 14-17 joints; terminal claw hook-like. The first pinnule occurs on the 4th-5th brachial. Arms smooth; disk covered with small calcareous granules.



FIG. 11.—*Pentametrocrinus atlanticus*. (After Perrier, *Explorations sous-marines*.) Nat. size.

The figure is incorrect. The cirri are too long, and they end in a hook, not as here shown. (Cf. *Monaco xxxiv. Pl. XXXII. 17.*)

It is a very fragile species; the specimens as a rule are badly broken and incomplete when brought to the surface.

Found off S.W. Ireland, ca. 1100-1300 m. ("Helga"). Known

elsewhere from the Bay of Biscay to the Canaries, and from the West Indies (off Martinique). Bathymetrical distribution ca. 600-2100 metres.

[Family THALASSOMETRIDÆ]

Of this family, the characters of which appear from the key on p. 16, three genera are represented in the N.E. Atlantic, and may well be supposed to occur also in the deep sea off Ireland. These are: *Crotalometra* A. H. Clark, with the two species *Cr. porrecta* (P. H. Carpenter) (syn. *Antedon porrecta* P. H. Carp.), known from the Bay of Biscay, 1480 m. ("Talisman") and from off Ascension, 768 m. ("Challenger"), and *Cr. flava* (Koehler) (syn. *Antedon flava* Koehler) from the Bay of Biscay, 1410 m. ("Caudan"), and 25° 39' N., 18° 22' W., 882 m. ("Talisman"); *Stiremetra* A. H. Clark, with the species *St. lusitanica* (P. H. Carpenter) (syn. *Antedon lusitanica* P. H. Carp.) from off Portugal to the Canaries, ca. 915-2165 m. ("Porcupine", "Talisman", "Princesse Alice"), and *Thalassometra* A. H. Clark, with the species *Th. omissa* (Koehler) (syn. *Antedon omissa* Koehler) found off Teneriffe, Canaries, 1330-1340 m. ("Princesse Alice"), only a single specimen known. The three genera are thus distinguished:

1. Arms usually 10, rarely as many as 13 2
 „ „ 20, proximal arm-joints smooth
Crotalometra A. H. Cl.
2. Proximal arm-joints smooth, but with a more or less prominent median keel *Stiremetra* A. H. Cl.
- Proximal arm-joints more or less thickly studded with spines, especially on the edges; no median keel
Thalassometra A. H. Cl.

The two species of *Crotalometra* are thus distinguished:

- Cirri with 40-50 joints, the longest of which are only slightly longer than broad; proximal arm-joints not with the distal edge turned outwards and produced *Cr. porrecta* (P. H. Carp.)
- Cirri with ca. 30 segments, the longest of which are ca. twice as long as broad; proximal arm-joints with the distal edges turned outwards and produced . . . *Cr. flava* (Koehler)

IV. Family ANTEDONIDÆ

Free, unstalked Crinoids. Cirrus-sockets not bordered by a horseshoe-shaped raised rim. Arms 10, dividing on the second post-radial joint (the axillary).¹

¹ This diagnosis, combined with the characters given in the key to the families of Crinoids of the European seas (p. 16), is sufficient for

This large family is subdivided into several subfamilies. Seven genera are represented in British seas. One more, *Thaumatometra* A. H. Clark, is likely to be found there also, viz. the species *Th. septentrionalis* A. H. Clark, hitherto known only from S.W. of Iceland, 2075 metres.¹ This genus is therefore included in the key, but not otherwise mentioned in the text.

Key to the subfamilies and genera of the family Antedonidae known from or likely to be represented in British seas.

1. Cirrus-sockets arranged in columns on a conical or columnar, usually large, centro-dorsal. Subfam. *Zenometrinæ* . . . 2
- Cirrus-sockets arranged in transverse alternating rows or irregularly. Centro-dorsal hemispherical, discoidal or conical . . . 3
2. Pinnule₁ usually about three times as long as P₂ . . . 2. *Poliometra* A. H. Cl.
- Pinnules₁₋₂ both elongated and similar, markedly longer than P₃ . . . 3. *Leptometra* A. H. Cl.
3. Pinnule₁ composed of numerous (ca. 50) short segments, of which at least the first six or seven, usually nearly all, are broader than long, the distal rarely more than twice as long as broad. Subfam. *Heliometrinæ* . . . 7. *Heliometra* A. H. Cl.
- Pinnule₁ composed for the most part of much elongated segments, though a few of the basal segments may be short; the distal segments at least twice as long as broad . . . 4
4. Distal cirrus segments entirely without dorsal processes on their distal ends (Fig. 12, 2). Cirri usually short, rarely with more than 20, never more than 30, segments. Subfam. *Antedoninæ* . . . 1. *Antedon* de Frém.
- Distal cirrus segments always with dorsal edge produced in the form of a dorsal spine (Fig. 12, 1). Cirri usually long, 12-40 segments; very fragile, often broken. Subfam. *Bathymetrinæ* . . . 5
5. All the cirrus segments short, the longest not so much as twice as long as the median diameter . . . 6. *Orthometra* A. H. Cl.
- Some of the proximal cirrus segments elongated, at least twice as long as the median diameter, usually much longer . . . 6
6. All the brachials with strongly produced and very spinous edges . . . 5. *Trichometra* A. H. Cl.

distinguishing this family from the other families represented in European seas. A much more elaborate diagnosis would be needed for distinguishing it also from all the non-European families of Comatulids, which would, however, be outside the scope of a book like the present.

¹ A detailed description of this species is found in A. H. Clark's report on the Crinoids of the Danish "Ingolf" Expedition (vol. iv. 5, 1923, p. 12).

Brachials not strongly produced, at most the distal edges of the outer brachials bordered with fine spines 7

7. Pinnule₁ much elongated, 2-3 times as long as P₂

7. *Hathrometra* A. H. Cl.

Pinnule₁ scarcely longer than P₂

Thaumatometra A. H. Cl.



FIG. 12.—Cirri of *Hathrometra Sarsii* (1) and *Antedon petasus* (2). $\times 6$.
(From *Danmark's Fauna*.)

Subfamily ANTEDONINÆ

1. *Antedon* de Fréminville.

Centro-dorsal hemispherical, not wholly covered with cirri, the apex remaining naked. Cirri without dorsal processes on their distal ends, usually short, rarely with more than 20, never more than 30, segments. Pinnule₁ about twice as long as P₂, the latter as long as P₃.

Two species are found in the British seas. A supposed third species, *Antedon Milleri* Wyv. Thomson, is not recognisable, and is probably identical with *A. bifida*. Three more species are found in the Mediterranean, one of these, *A. moroccana* A. H. Clark, is also distributed along the Atlantic coasts of Africa, down to Senegal, and even to the Azores. But as it is not known from north of Gibraltar there is scarcely any probability of its occurring in the British seas. (Keys to all the Atlantic species of the genus

Antedon are found in A. H. Clark's reports on the Crinoids of the Danish "Ingolf" Expedition (Vol. IV., 1923, p. 55), and on the Comatulids of the Siboga Expedition (Monogr. XLII. 6, 1918, p. 203.).

Key to the British species of the genus Antedon.

Distal edge of brachials thickened and prominent (Fig. 13.₁)

1. *A. bifida* (Penn.)

Distal edge of brachials not thickened and prominent (Fig. 13.₂)

2. *A. petasus* (Düb. and Kor.)

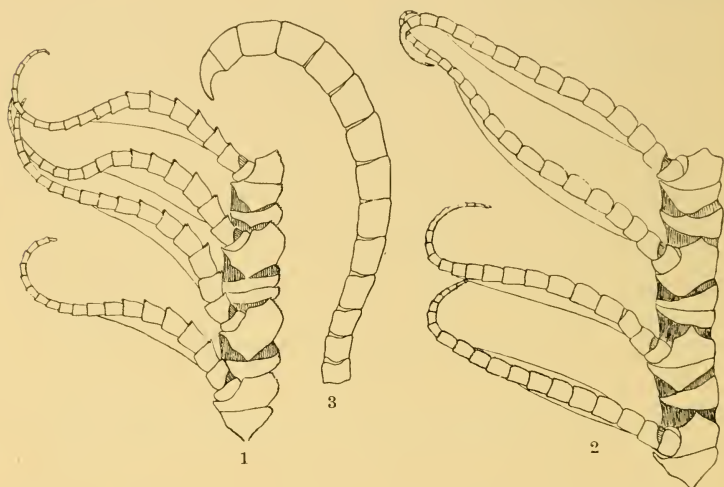


FIG 13.—Part of arm (side view), with genital pinnules, of *Antedon bifida* (1) and *petasus* (2); a cirrus of *A. bifida* (3). $\times 7$.

1. *Antedon bifida* (Pennant). (Fig. 14.)

(Syn. *Antedon rosaceus* (Linck); ? *Antedon Milleri*
Wyv. Thomson.)

Cirri usually ca. xxv, with rarely more than 15 segments, increasing in width very gradually (Fig. 13₃). Pinnule₁ with ca. 35 segments. Distal edge of brachials thickened and prominent (Fig. 13₁). Proximal 6-7 joints of genital pinnules with rather prominent spines at the distal outer corner; beyond these the pinnule joints diminish rapidly in size (Fig. 13₁); genital organ confined to basal half of pinnule. Colour in life very variable—rosy to deep purple, yellow or orange, or mottled and spotted.

The eggs are attached in clusters to the genital pinnules, the larva not leaving the egg-membrane until the ciliated bands have

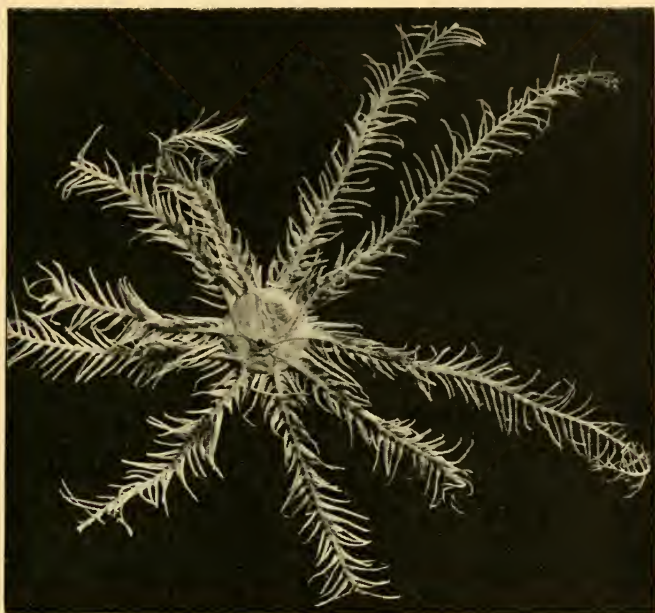


FIG. 14.—*Antedon bifida*, seen from above (the oral side). Nat. size.

formed. The Pentacrinoids (Figs. 15-16) may be found in great numbers on Hydroids, wormtubes, algæ, etc., in places where the adult abounds, the latter also generally living together in great numbers. It prefers hard bottom, with shells, Hydroids, and the like.

Two species of *Myzostoma* infest this species, viz. *M. parasiticum* Leuckart and *M. cirriferum* Leuckart. A peritrichous Infusorian, *Hemispieiropsis antedonis* Cuénot, occurs among the cirri on the centro-dorsal.

Along the British coasts this species appears to occur from the Channel round the west coasts to the Shetland Islands and down to Northumberland, but not farther south on the east coast. Also known from the Channel Islands and southward to Portugal.



FIG. 15.—Pentacrinoids of *Antedon bifida* attached to a piece of Hydroid. Nat. size. To the left numerous very young specimens, to the right some older specimens, of an age corresponding to that of the Pentacrinoid represented in Fig. 16.

Bathymetrical distribution ca. 5-200 m.; exceptionally recorded also from 450 m. W. of Ireland.¹

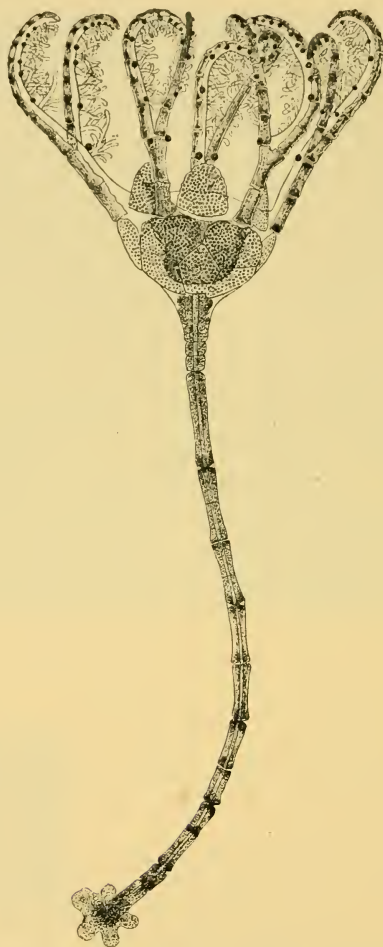


FIG. 16.—A Pentacrinoid, nearly fully formed, but still without cirri or pinnulæ. Note the large oral plates. (After Chadwick.) \times ca. 14.

2. *Antedon petasus* (Düben and Koren).

Cirri usually ca. L., with 11-17, more generally 15, segments; they very much resemble those of *A. bifida* (Fig. 12₂; compare

¹ The records in older literature are scarcely reliable, since a confusion of the two species *bifida* and *petasus* is likely to have taken place. The *Antedon* "*rosaceus*" from the Rockall Bank probably is either *bifida* or *petasus*.

with Fig. 13₃). Pinnule₁ with ca. 30 segments. Distal edge of brachials not thickened and prominent (Fig. 13₂). Pinnule joints very gradually decreasing in size, none of the proximal joints with prominent spines at outer edge. Genital organ extending beyond basal half of the pinnule. Colour in life very variable, yellow or red-brownish, or a deep purple, to nearly white; often very conspicuously banded.

The eggs are not attached in clusters to the pinnules, but dropped free into the water. The larva leaves the spiny egg membrane uniformly ciliated, the ciliated bands only appearing later. The *Pentacrinoid* (Fig. 17) is somewhat coarser than that of *A. bifida*; the stalk has ca. 25 segments. Only the younger stages of this *Pentacrinoid* are known, and only very few specimens have been found; the longer swimming period of the larva accounts for the fact that the *Pentacrinoids* are found very scattered, attached to algæ, Hydroids, etc.

Two species of *Myzostoma* occur on this Comatulid, viz. *M. cirriferrum* Leuckart and *M. parasiticum* Leuckart. Also a species of *Loxosoma* occurs on its pinnules.

In British seas this species is known with certainty from off S.W. Ireland and the Orkney Islands. It is therefore almost certain that it will prove to occur all along the west coasts of Great Britain; very probably it will be found to occur also some way down the North Sea coasts. Elsewhere it occurs at the Faroe Islands, Iceland, and the Scandinavian coasts as far north as Tromsö. Bathymetrical distribution, ca. 20-325 m.

As this is a more northern species than *A. bifida* it is to be expected that in the more southern parts of its range it will be found mainly in the deeper and colder waters, while the more southern

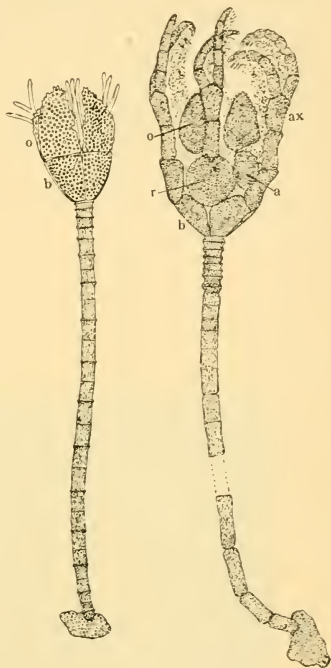


FIG. 17.—*Pentacrinoids* of *Antedon petasus*. In the larger specimen nine stalk-joints have been omitted. The smaller specimen $\times 40$, the larger $\times 20$. a, Anal plate; ax, Axillary; b, Basal; o, Oral; r, Radial plates. (From *Danmark's Fauna*.)

species, *A. bifida*, is likely to prefer shallower water, at least on the southern coasts of Great Britain.

Subfamily ZENOMETRINÆ

2. *Poliometra* A. H. Clark.

Centro-dorsal conical with cirrus-sockets arranged, more or less distinctly, in vertical columns. Segments of the cirri longer than broad, swollen at the articulations, but not with very prominent dorsal processes. Brachials smooth, without prominent spines on the distal edge. Pinnule₁ much elongated, usually ca. 3 times as long as P₂.

Only one species in European seas (the only species known of the genus).

1. *Poliometra proluxa* (Sladen). (Fig. 18.)

(Syn. *Antedon*, *Hathrometra proluxa* Sladen.)

Cirri ca. lx-lxx, with ca. 40 segments, very long and slender, ca. 4 times as long as broad in the middle of the cirrus. The



FIG. 18.—*Poliometra proluxa*. Nat. size. (From Th. Mortensen, *Echinod. N.E. Greenland*.)

terminal joint forms a delicate hook, and there is a fairly distinct opposing spine on the penultimate joint. The first pinnule has

ca. 26-27, the second and third 11 joints. The outer pinnule joints slender, cylindrical, smooth. Colour : pinnules yellow-red, arms brown-yellow, disk light brown, cirri white.

Eggs probably free. The *Pentacrinoids* may be found attached to the cirri of the adult. The younger stage is characterised by the prominent, outwardly-turned edge of the orals

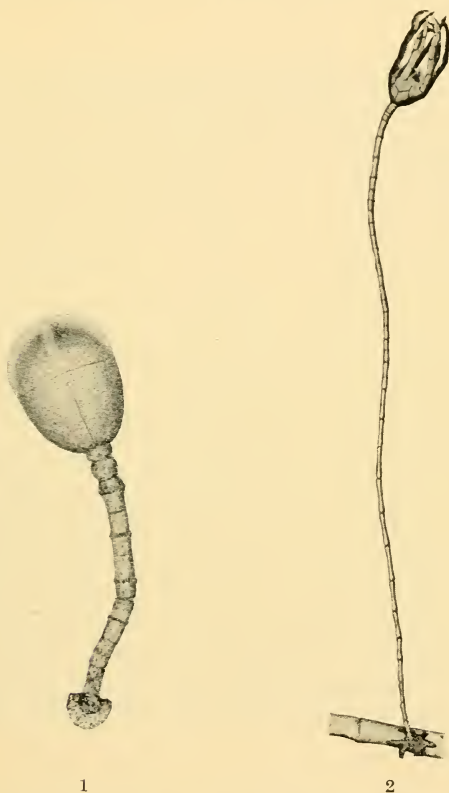


FIG. 19.—Pentacrinoids of *Poliometra proliza*, a very young stage (1) and a later stage, where the arms have already begun to branch, but the cirri have not yet appeared. (From Th. Mortensen, *Echinod. N.E. Greenland.*) 1×45 , 2×8 .

(Fig. 19, 1); in the older stages the stalk is very slender and long, ca. 12-13 mm., with ca. 33-35 joints (Fig. 19, 2).

An Entoproct Bryozoan, *Loxosomella antedonis* Mrtsn. has been found on the cirri of this species, and no less than four species of *Myzostoma* are found on it, viz. *M. giganteum* Nansen, *M. Graffi* Nansen, *M. Carpenteri* v. Graff, and *M. cirriferum* Leuckart.

In British seas this species is confined to the cold area of the Faroe Channel, where it has been found a few times ("Porcupine," "Triton," "Silver Belle," "Michael Sars"). It is an arctic species, ranging from west and east Greenland to the Kara Sea, and as far south as the cold area extends. Known bathymetrical range, 24-1960 m.

3. *Leptometra* A. H. Clark.

Rather similar to *Poliometra*, from which it differs especially in the relative length of the oral pinnules, the two first being equally long, and markedly longer than P_3 . Another important difference is found in the size of the cavity of the centro-dorsal, which is much larger in *Poliometra* than in *Leptometra*.¹

Only one species in the British seas (and in the Atlantic).

1. *Leptometra celtica* (Barrett and McAndrew). (Fig. 20.)

(Syn. *Comatula Woodwardi* Barrett; *Antedon phalangium* P. H. Carpenter; non: *Antedon phalangium* Joh. Müller.)

Cirri ca. xx-xxx,² with ca. 40-50 joints; in the proximal part the joints are about twice as long as broad, in the distal part they are only about as long as broad, at most one-third longer than broad, and have the distal dorsal edge somewhat swollen, so that the dorsal profile of the cirri is slightly scalloped. The cirri, on the whole, somewhat stouter in the distal part. The first two pinnules with ca. 20 segments, the outer ones slender, elongated. Colour in life green,³ fades in alcohol to a pale brown.

Pentacrinoid stage unknown. Two species of *Myzostoma* occur on this Comatulid, viz. *M. alatum* v. Graff and *M. pulvinar* v. Graff.

In British seas this species has been found at the Minch, Skye (abundant in ca. 70-100 m.), off the N. coast of Scotland, and off S.W. Ireland ("Porcupine," "Flying Fox," "Helga").

¹ Cf. Gislén, *Echinoderm Studies*, p. 217, figs. 301 and 302.

² Bell (*Catalogue of the British Echinoderms*, p. 59) gives the number of the cirri as xxxv-xlv. A. H. Clark (*Notes on the Recent Crinoids in the British Museum*, 1913, p. 57) states their number to be xiv-xxiv. The present author has found the number to be ca. xx-xxx. The discrepancy would seem to indicate an unusual amount of variation in the number of the cirri in this species.

³ This statement of the colour, given in Bell's *Catalogue*, very probably refers only to the Mediterranean species, the true *phalangium*; the colour of *L. celtica* is, in fact, unknown.

Southwards it extends to Madeira and the southern border of Morocco. Known bathymetrical distribution, 46-1279 m.

(Another species, *Leptometra phalangium* Joh. Müller, occurs in the Mediterranean, but is not known with certainty from the Atlantic. It is easily distinguished from *L. celtica* by its more slender cirri; the joints of the distal part are not shorter than the proximal ones, all being about twice as long as broad; also



FIG. 20.—*Leptometra celtica*. Nat. size.

the distal dorsal edge of the joints is not swollen. The species recorded from British seas as *Antedon phalangium* is not really this species, but *Leptometra celtica*.)

Subfamily HELIOMETRINÆ

4. *Heliometra* A. H. Clark.

Centro-dorsal hemispherical, with cirrus-sockets irregularly arranged. Cirri rather stout; the proximal segments somewhat longer than wide, the distal short, with more or less prominent dorsal spine. Oral pinnules greatly elongated and flagellate,

composed of very numerous short and wide joints ; the distal part of these pinnules more or less serrate.

Only one species in British seas.

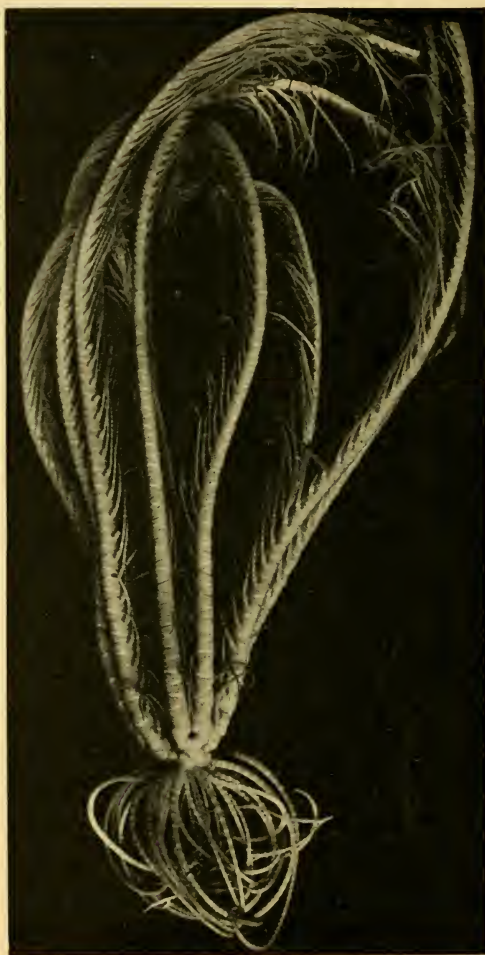


FIG. 21.—*Heliometra glacialis*. Nat. size.

1. *Heliometra glacialis* (Leach). (Fig. 21.)

(Syn. *Antedon Eschrichtii* Joh. Müller, *Heliometra Eschrichtii* (Joh. Müller) ; *Antedon quadrata* P. H. Carpenter.)

Cirri very numerous, about a hundred or more, covering nearly the whole of the centro-dorsal ; they have mostly ca.

40-60 joints. Brachials usually smooth. Pinnule₂ of about the same length as P₁. The genital pinnules with fairly large calcareous plates in the side walls.

This is a large and stout species, reaching an arm length of 200 mm. or even more. Colour in life yellowish. It is infested with a large species of *Myzostoma*, *M. gigas* Lütken, and also with *Myzostoma fimbriatum* v. Graff. The Entoproct Bryozoan *Loxosomella antedonis* Mrtsn. also may occur on this species.

The eggs probably are free; the Pentaerinooids are only rarely found and only a few stages are known. The stalk-joints are rather stout (Fig. 22).

In British seas this species occurs only in the cold area of the Faroe Channel. It is an arctic species, probably of circumpolar distribution, the form occurring in the North Pacific being only regarded as a separate variety, var. *maxima* A. H. Clark, which grows to a larger size than the Atlantic form. Bathymetrical distribution, ca. 10-1350 m.

Subfamily BATHYMETRINÆ

5. *Trichometra* A. H. Clark.

Centro-dorsal subconical, thickly covered with small, crowded cirrus-sockets. Cirrus segments elongate in the proximal half of the cirrus, at least twice as long as the median diameter, usually longer, squarish in the distal part, these latter joints having a sharply carinate dorsal surface which projects more or less distally, giving a slightly spinous appearance. Small cirri, sometimes less than half the length of the other cirri, consisting of 10-12 very slender and much elongated joints, with greatly expanded articulations, occur around the dorsal pole of the centro-dorsal. Pinnule₁ very slender, composed of much elongated joints, especially distally, with distal ends much widened. Brachials with strongly produced and very spinous distal edges.

Only one species known to occur in British seas.



FIG. 22.—Pentaerinooid of *Helimetra glacialis*. (After Levinsen, *Kara - Havets Echinod.*) $\times 6$.

1. *Trichometra delicata* A. H. Clark. (Fig. 23, 1.)

Cirri very numerous, with ca. 20-33 segments; the longer proximal segments are ca. 3 times as long as broad in the middle, with the end much widened, partly covering the base of the following joint. The lower brachials strongly convex dorsally and laterally, just in contact with the adjoining ones, but not flattened against them. Arms scarcely reaching a length of 40 mm. Colour in life unknown. Pentacrinoid stage unknown.

In British seas this species has been found only off the W. Coast of Ireland ($53^{\circ} 58' N.$, $12^{\circ} 24' W.$, 382 fms., "Helga"). Elsewhere it is known from off Portugal and S.W. of Iceland. Known bathymetrical distribution, 700-2075 metres.

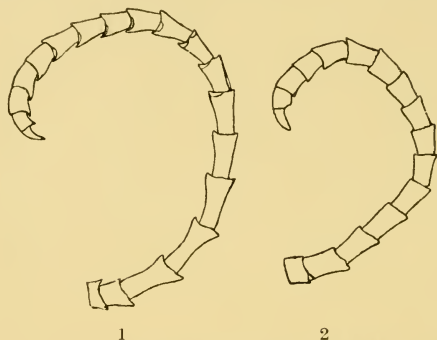


FIG. 23.—Cirri of *Trichometra delicata* (1) and *Orthometra hibernica* (2). $\times 10$.

Another species, *Trichometra cubensis* Pourtalès, has been found S. of Iceland and W. of the Faroe Islands and may therefore be expected to occur also off the coasts of Ireland. It differs from *Tr. delicata* in the lower brachials being only slightly convex dorsally, and sharply and broadly flattened against their neighbours. The arms reach a length up to 65 mm. It is known also from the Western Atlantic, from Cuba to Davis Strait, from depths of ca. 225-2200 metres.

A third species, *Trichometra minutissima* (A. H. Clark), which has been found only off Brazil, 1495 metres, is not likely to occur in British seas.

6. *Orthometra* A. H. Clark.

Differs from *Trichometra* and *Hathrometra* in all the cirrus segments being short, the longest not so much as twice as long as the median diameter. The segments are cylindrical; the

distal ends not expanded. The lower brachials not joining their neighbours.

Only one species found in British seas, the only known species of this genus.

1. *Orthometra hibernica* (A. H. Clark). (Fig. 23, 2.)

(Syn. *Trichometra hibernica* A. H. Clark.)

Cirri very numerous, completely covering the centro-dorsal ; short, ca. 13 mm. long, with ca. 15-33 segments. The distal segments have a median dorsal carination. The lower brachials have everted and serrate distal edges. A small and delicate species.

Colour in life unknown. Pentacrinoid stage unknown.

Hitherto found only W. of Ireland (" Helga ") and S.W. of the Faroe Islands (" Ingolf "), in depths of ca. 700-1000 metres.

7. *Hathrometra* A. H. Clark.

Centro-dorsal subconical, with numerous, crowded cirrus sockets. Cirri long and slender, the proximal joints elongated ; much longer than the distal (Fig. 12, 1). Brachials not with strongly produced and very spinous distal ends. Pinnule₁ much elongated, 2-3 times as long as P₂.

Only one species known from British (and European) seas.

1. *Hathrometra Sarsii* (Düben and Koren). (Fig. 24.)

(Syn. *Antedon Sarsii* Düben and Koren ; *A. tenella* Retzius ;
Hathrometra norvegica A. H. Clark.)

Cirri numerous, with ca. 20 (14-23) joints ; those on the apex of centro-dorsal smaller and with fewer joints. Pinnule₁ composed of 30-40 segments ; a few of the basal segments are short, the following becoming slender and greatly elongated ; P₂ very much shorter, with only a few joints. Colour in life greyish, with indistinct, brown transverse bands.

It is a slender and fragile species, which is very liable to throw off its arms on being taken out of the water ; good, complete specimens are therefore rather difficult to obtain.

The first developmental stages unknown, but probably the eggs are free. The *Pentacrinoids* have a long and slender stalk composed of up to ca. 40 very slender segments. The young feather-star does not detach itself until a rather late stage, when 20-30 cirri have appeared and the arms have 5-6 pinnules on each side (Fig. 25).



FIG. 24.—*Hathrometra Sarsii*. Nat. size. (From *Danmark's Fauna*.)

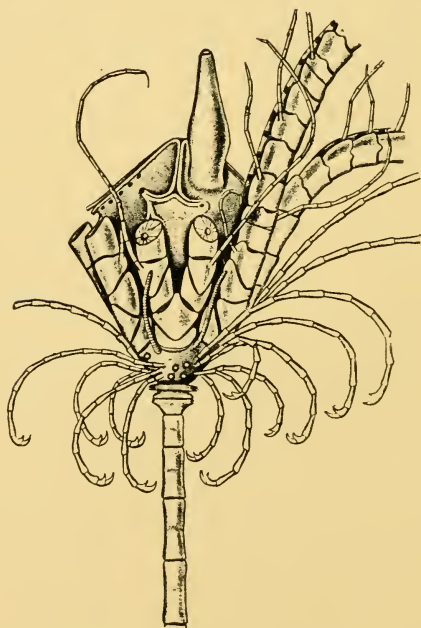


FIG. 25.—Pentacrinoid of *Hathrometra Sarsii* in an advanced stage of development, ready to detach itself from the stalk. Numerous cirri have developed. Only the basal part of arms and the proximal part of stalk represented. Note the large anal cone. (After M. Sars.) \times ca. 6.

It is only rarely infested with *Myzostoma* (*M. Carpenteri* Graff). A small Isopod, *Munna Boeckii* Kröyer, is not infrequently found on its arms, crawling about among its pinnules and gnawing off its tube-feet—which does not appear to irritate the sea-lily. On account of its grey colour the Isopod is very difficult to observe on the sea-lily.

Known in British seas from S.W. of Ireland to the Shetlands, from depths of ca. 300-500 ms. (The *Antedon tenella* recorded from Lousy Bank is probably this species.) Elsewhere widely distributed in the North Atlantic (Faroes, Iceland, S.W. Greenland) and along the Norwegian coast to Finmark. Also off the American coasts it is found in deep water southward to Massachusetts and New York. Known bathymetrical distribution, 28-1783 metres.

A very closely related form, *Hathrometra tenella* (Retzius), occurs at the east coast of N. America. It is distinguished through the somewhat larger number of cirrus-segments (mostly 27-30), and is, upon the whole, somewhat larger (arms usually 85-100 mm. long, in *H. Sarsii* rarely more than 85 mm. long). It seems, however, doubtful whether the two forms can be maintained as separate species; they are probably only varieties of one and the same species. If the latter view is correct, the European form should be named *Hathrometra tenella*, var. *Sarsii* (Düben and Koren).

II. CLASS. SEA-STARS¹ OR ASTEROIDS

(ASTEROIDEA)

Free-living echinoderms, with a flat, star-shaped, or pentagonal body. Tube-feet in an open furrow along the underside of the arms, which are, as a rule, not sharply marked off from the disk. The arms contain the genital organs and the "pyloric cæca" (liver). Stomach large, sac-shaped; intestine rudimentary; anal opening small or wanting. Mouth turning downwards.

The *body* of the sea-stars is of very different size, in accordance with the development of the arms. The *arms* or *rays* may be very short and broad—in this case the body or the disk is large, the

¹ It has been thought desirable to use the designation "sea-stars" for this class of animals instead of the more popular but misleading "star-fishes"; "sea-star" also is preferable as corresponding to the designation used in most other civilised languages—"Seestern", "Étoile de mer", "Søstjerne", etc.

whole animal being pentagonal (*e.g. Ceramaster, Porania*)—or they may be very long and rather narrow, and then the body is quite small (*e.g. Asterias, Luidia*). The relation between the length of arms and the diameter of disk is of systematic importance; the distance from the centre of disk to the point of the arm is designated R , the distance from the centre to the edge of disk midway between the arms, r . When it is stated, for example, that $R=5r$, it means that the distance from the centre of the disk to the point of the arms is five times as large as the distance from the centre to the edge of the disk. Mostly the arms pass gradually, without marked limit, into the disk, but sometimes there is a distinct constriction at the base of the arms (*Asterias*); in *Brisinga* the limit between disk and arms is sharp and distinct. The number of the arms is commonly 5, but in some forms (*Solaster, Brisinga*) there are more (9-15) arms, and in some exotic forms even many more (25-40), the number increasing with age. Of normally 5-rayed species, specimens with 4 or 6 arms may occur. Sometimes an arm may be bi- or tripartite. The arms have an internal skeleton consisting of paired plates, the *ambulacral plates*, which form a structure like a vertebral column. In some forms (*Astropecten*) a small plate, the *superambulacral plate*, is found internally within the arms, one above each ambulacral plate. On the under side of the arm there is an open furrow, the foot-groove or *ambulacral furrow*, limited on each side by a series of distinct plates, the *adambulacral plates*, one to each ambulacral plate. In the bottom of the furrow the *tube-feet* are found, arranged in two series; in some forms they are arranged in four series, which is due to an alternating displacement of the two original series. The tube-feet issue from between the ambulacral plates. They are very extensile, soft, and flexible, without skeletal parts, and generally terminate in a sucking disk (wanting in *Astropectinids*). The *ampullæ* of the tube-feet form very conspicuous series of vesicles along the inside of the ambulacral plates, and are very easily seen on opening the arms from the dorsal side; they may be single or double, a character of some systematic value. At the point of the arm there is an unpaired tentacle, carrying on its underside a red pigment-spot, a rather well-developed *eye*, provided with a sort of lens. The point of the arms is always bent upwards so that the eye is not obscured. At the point of the arm there is, above the tentacle, a larger unpaired plate, the *terminal plate*.

Along the edges of the ambulacral furrow, on the *adambulacral* plates, are found some regularly arranged *adambulacral* or *furrow*

spines or *papillæ*, generally somewhat larger than the other spines on the underside ; they are of very great systematic importance. Along the edge of the disk there is in some forms a double—more rarely (*Luidia*) a single—series of large, distinct plates, the *marginal plates* ; they are mostly covered with fine granules or spines of varying size. The space between the arms on the under side of the disk forms, where marginal plates are present, or where there is a distinct limit between the upper and under side, a well-defined area, the *oral interradial area* ; it has, as a rule, a characteristic covering of spines, different from that of the upper (dorsal) side. The skin of the dorsal side is supported by a skeleton of calcareous plates, with a reticular arrangement. On these plates spines are articulated, scattered or in groups, or arranged in regular bundles, attached to shaftlike processes from the plates. Such groups of spines are designated *paxillæ*¹ and bear some resemblance to a brush. Where *paxillæ* are found, the spiny covering of the dorsal side often forms a regular, beautiful mosaic. In some forms (*Porania*) the skin of the dorsal side is perfectly naked. In the skin, between the spines, pores occur, through which delicate tubes, *papulæ*, may be extended (Fig. 2 G) ; they have the function of *gills*, and in some forms (*e.g.* *Asterias*) may be so numerous that, when well extended, they make the animal look quite shaggy. On the dorsal side, about half-way between the edge and the centre of the disk, lies the *madreporite*, which is generally rather large and conspicuous ; it is finely striate. Exceptionally, there may be 2-3 madreporites ; a tropical, many-rayed sea-star (*Acanthaster*) has numerous madreporites.

In most sea-stars are found peculiar small organs, small pincers, the *pedicellariæ* (Fig. 26). In their simplest shape they are only common spines, placed 2-4 together so that they can move against each other (*Astropecten*, *Pontaster*), or two series of spines opposed to one another (pectinate *pedicellariæ* ; *Pseudarchaster*) ; in others they have the shape of two small, or two very broad, low valves (valvate *pedicellariæ*, *Ceramaster*, *Hippasteria*), or narrow valves attached in deep grooves (alveolate *pedicellariæ*). In more developed form they consist of two peculiar-shaped valves, which move on a basal joint ; of these there are usually two forms, the crossed and the straight *pedicellariæ* (or in older terminology, forcifiform and forcipiform *pedicellariæ*) (*Asterias*, *Brisinga*). They are attached to the skin

¹ The finer distinction between the various forms of spine-groupings : *paxillæ*, *pseudopaxillæ*, *parapaxillæ*, etc., it seems unnecessary to emphasise in the present work.

by means of a more or less distinct, soft stalk. Often they are collected in a large cushion round the base of the larger spines. In living specimens these cushions generally rise to the point of the spine, while in preserved specimens they are, as a rule, retracted to the base of the spine. Straight pedicellariæ are often found attached to the adambulacral spines.

Special organs of another kind are the so-called "*cribriform*" organs, peculiar to the family Porcellanasteridæ (and Gonio-

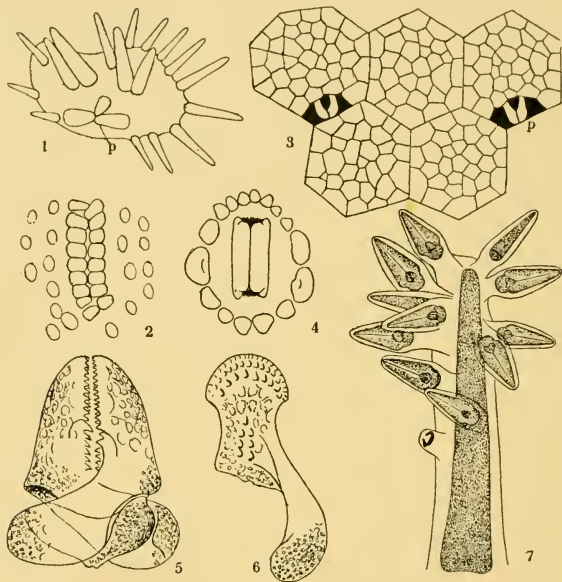


FIG. 26.—Various sorts of pedicellariæ of Asteroids.
(From *Danmark's Fauna*.)

1. Simple type (*Pontaster tenuispinus*). $\times 13$. 2. Pectinate pedicellaria (*Pseud-archaster Parelii*). $\times 13$. 3. Paxilla-like groups of grains from the dorsal side of *Ceramaster granularis*, with two valvate pedicellariæ. $\times 13$. 4. Bivalve pedicellaria of *Hippasteria phrygiana*. $\times 6$. 5. Crossed pedicellaria of *Asterias rubens*. $\times 120$. 6. Valve of the same, seen from the inside. $\times 120$. 7. Group of straight pedicellaria on an adambulacral spine of *Asterias rubens*; the small, lowermost one just beginning to form. $\times 10$. p, Pedicellaria.

pectinidæ). These are parallel skin-folds, sometimes divided into papillæ, which are then serially arranged; each fold is supported by some delicate calcareous plates. They are situated between the marginal plates (Fig. 27), bounded on each side by a series of scale-like papillæ, like a web, which may (*Otenodiscus*) conceal the whole of the organ. In many forms there are very fine spines in the furrows between the marginal plates, covered by a thick, ciliated skin; they may be designated *fascioles*. These, as well as the cribriform organs, which are also strongly

ciliated, are supposed to have a respiratory function ; it appears that the cribriform organs also act as a sieve to get rid of the coarser bottom material (the Porcellan-asterids being mud-eaters).

The *mouth* is on the underside, in the middle, where the ambulacral grooves join. There are no teeth, but the innermost adambulacral spines are bent over the mouth edge, forming thus a sort of mouth armature. The stomach is large, sac-shaped, filling up nearly the whole disk. A pair of large, branched pyloric sacs (liver) proceed from the stomach into each arm. As a rule there is a short, thin rectum, from which some small rectal cæca may proceed. The anal opening, which is small and often difficult to observe, is situated in the centre of the disk. It is wholly wanting in some forms. In the genus *Luidia* both rectum, rectal cæca, and anal opening are wanting.

The *genital organs* are bush-shaped, branching bodies, attached to the base of the rays, one on each side ; when they contain ripe

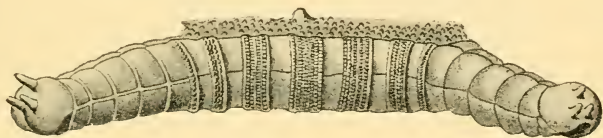


FIG. 27.—Side view of *Hyphalaster inermis*, showing cribriform organs. (After Sladen.)

sexual products they may extend far out into the rays. In some forms (e.g. *Luidia*) there is a series of small genital organs extending along each side of the arms, nearly to the point. The genital openings are situated at the base of the rays, sometimes on small papillæ ; they are generally difficult to observe. Some forms have several openings to each genital organ ; where there are series of genital organs, each single organ has its special opening.

The *nervous system* is not very highly developed ; the best developed part is the ambulacral nervous system, which is seen as an elevated median ridge in the ambulacral furrows.

The *colour*, which is often a beautiful red or violet, always disappears completely on preservation in alcohol. In formalin the colour will, in some forms, keep very beautifully for a longer period, and it will often keep well in dried specimens, when these have been preserved for some time in formalin.

Some of the sea-stars found in the British seas (*Henricia*, *Pteraster*, *Leptasterias Mülleri*) protect their brood ; in these cases the development is direct. In *Solaster*, and probably

several more sea-stars, the development is also direct, the larva being small, much reduced, and without a mouth. Most sea-stars, however, have a highly developed larva, *Bipinnaria* (see p. 6), which leads a pelagic life for a period usually of some weeks, feeding on Diatoms and other small pelagic organisms. In some *Bipinnariæ* (the larvæ of *Asterias* and *Porania*) the three anterior

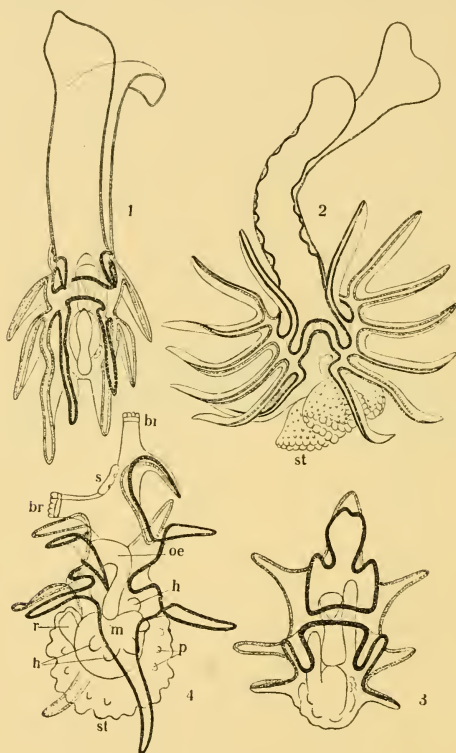


FIG. 28.—Larvæ of Asteroids. (From *Danmark's Fauna*.)

1. Young Bipinnaria of *Luidia* (*Sarsii*?). $\times 16$. (After Garstang.) 2. Bipinnaria of *Luidia Sarsii*, near metamorphosis; in the posterior end is seen the young sea-star. $\times 3$. (After Joh. Müller.) 3. Bipinnaria of *Astropecten irregularis*. $\times 35$. 4. Brachiolaria stage of the larva of *Asterias rubens*; in the posterior end is seen the rudiment of the young sea-star. $\times 10$. br, Brachiolaria arms; h, Hydrocoel; m, Stomach; oe, Oesophagus; p, Spines; r, Rectum; s, Sucking disk; st, Sea-star.

ventral arms are provided with small papillæ, arranged in a whorl round the point or in a series along each side of the arm. At the base of these arms there is a large sucking disk, by means of which the larva may attach itself (during metamorphosis). Such larvæ are said to have a *Brachiolaria* stage, or are designated by the name *Brachiolaria*. The arms provided with these papillæ are called *Brachiolaria* arms (Fig. 3, 2; Fig. 28).

Key to the larvæ of Asteroïds (Bipinnaria¹). (Fig. 28.)

- | | |
|--|--------------------|
| 1. Anterior part of body much prolonged | <i>Luidia</i> |
| " " " not " | 2 |
| 2. The fully formed larva a Brachiolaria | 3 |
| " " " not a Brachiolaria | <i>Astropecten</i> |
| 3. Papillæ in a whorl round the point of the Brachiolaria-arms | <i>Asterias</i> |
| Papillæ in a series along the sides of the Brachiolaria-arms | <i>Porania</i> |

The sea-stars are slowly moving animals, which proceed with a sliding movement over the bottom, progressing on the points of the tube-feet.² The sucking disks are generally not used when walking on smooth bottom, but only when climbing. Most of them are very voracious, eating all sorts of animals, especially echinoderms, molluscs, and worms. They are able to swallow

relatively large animals, the mouth being very extensible; but even such animals as are too large to be swallowed — *e.g.* fishes — they are able to devour, by protruding the stomach over them, thus digesting them outside their body. Mussels also which are too large to be swallowed they are able to manage. The sea-star then assumes a characteristic position above the mussel, joining the arms round it, while raising its back (Fig. 29). Through the steady, uniform pull of the tube-feet the mussel is forced to open

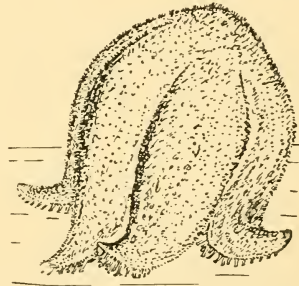


FIG. 29. — Sea-star (*Asterias rubens*) in the act of devouring a mussel. (After H. Blegvad; from *Danmark's Fauna*.)

its valves; the sea-star then protrudes its stomach and the mussel, which is probably paralysed by the juice of the sea-star's stomach, is thus devoured. The sea-stars in this way do great harm to oyster cultures. Fishes also are attacked by sea-stars, but, of course, mainly such as are hanging in nets and thus unable to escape. Some few sea-stars, *e.g.* *Ctenodiscus*, simply swallow

¹ Some other species of *Bipinnaria* have been described in the author's work, *Die Echinodermenlarven d. Plankton-Expedition*, 1898. Possibly some of these will prove to belong to sea-stars which occur also in British seas, but for the present nothing more definite can be said, and it must suffice to refer to that work.

² A tropical sea-star, *Luidia clathrata* (say); it is stated to be able to swim by means of its tube-feet.

the mud of the sea bottom, assimilating the organic substances and small organisms (*e.g.* Foraminifera) found therein. In some forms (*Ctenodiscus*, *Astropecten*, *Porania*, and others) ciliary movements on the oral side and in the ambulacral furrows play some part, leading a stream of microscopical particles to the mouth. Otherwise the main purpose of the ciliary currents is respiratory and cleansing.

The sea-stars are of no use to man; they are not used as food, such as is the case with sea-urchins and sea-cucumbers. Where they occur in great numbers, *e.g.* *Asterias rubens* in some Danish fjords, they might perhaps advantageously be used as manure.

It appears that sea-stars take, as a rule, about four years in reaching full size. For the present, however, little is known with certainty about this matter, as also nothing is known about how long a sea-star may live. With regard to the common sea-star, *Asterias rubens*, it is an established fact that the more abundant its food is, the faster it grows; it has also been shown that its rate of growth is faster in summer than in winter. The closely related American species, *Asterias vulgaris*, has been shown to reach a size of somewhat beyond 5 cm. length of arm in the course of four months, when a rich supply of food is available to it; probably the same will hold good for *Asterias rubens*. At least the larger specimens of this species are sexually mature when one year old.

The *regenerating power* is very great. Some species (*e.g.* *Marthasterias glacialis*, *Pedicellaster typicus*) amputate their arms close to the disk when they are hurt or are held under unfavourable conditions. This to a special degree holds good of *Brsinga*, which will very often amputate all its arms on being brought to the surface, so that one finds only the small disk and a number of isolated arms. Several forms, especially of the many-rayed (*e.g.* *Coscinasterias tenuispina*), divide through autotomy in two halves, each half then regenerating the lacking parts. In some tropical forms (*Linckia*) an amputated arm may regenerate the whole sea-star.

Parasites are not found in great numbers in Asteroids. A species of *Myzostoma* lives as entoparasite in the pyloric cæca of *Asterias Richardi*. A polychætous annelid of the Lepidonotids, *Acholoë astericola*, lives in the ambulacral grooves of *Astropecten*. Various species of parasitic snails (*Thyca*, *Stylifer*) are found on some tropical sea-stars. Some half-parasitic Copepods occur on Asteroids (*Astericola Clausi* on *Marthasterias glacialis*, *Astrochaeres Liljeborgi* on *Henricia sanguinolenta*). A

Caprellid, *Podalirius typicus*, is often found on *Asterias rubens*, but is hardly to be regarded as parasitic. Another Crustacean, *Dendrogaster*, a Cirripedian, is strictly parasitic, transformed into an irregular, branched body, without limbs, full of eggs and larvæ. It has been found in *Solaster* and *Henricia*, but is not known from British seas. A fish, *Fierasfer*, lives in the body cavity of a large tropical sea-star, *Culcita*; probably it enters through the mouth of the sea-star and must then pierce its way into the body cavity through the wall of the stomach.

Fossil Asteroids are not very numerous and mostly poorly preserved; accordingly they do not play so important a rôle in geology as do Crinoids and Echinoids.

The classification of Asteroids is, in the main, fairly well established. There is a general agreement that they are naturally divided into the following main groups: *Paxillosa*, *Notomyota*, *Valvata*, *Spinulosa*, and *Forcipulata*; it is only questionable whether these may again be arranged in the two higher groups introduced by Sladen, the *Phanerozonia*, comprising the three first, and the *Cryptozonia*, comprising the two last. Recent authorities on the Asteroids incline to the view that the three first groups should be united in one order, the *Phanerozonia*, while the two latter are regarded as orders of equal rank with the *Phanerozonia*. This classification is adopted here.

Regarding the question which group represents the more primitive type, opinions differ. Most of the recent authorities on Asteroids regard the *Phanerozonia* as the most primitive type, but others hold that the *Spinulosa* represent the most primitive type. Palæontological evidence is strongest for the *Phanerozonia* as the more primitive, the oldest known Asteroids (*Cambraster*, from Middle Cambrium; *Archegonaster*, from Lower Ordovician) being decidedly of phanerozoniate type.

Key to the orders of Asteroids.

1. Marginal plates usually large and conspicuous. Papulæ mostly restricted to the dorsal side; pedicellariæ never of the crossed type; tube-feet in two series I. *Phanerozonia*
- Marginal plates usually inconspicuous. Papulæ generally also found on the oral side 2
2. Pedicellariæ, which are very rare, never of the crossed type. Spines of the dorsal side usually in groups; tube-feet usually in two series II. *Spinulosa*
- Crossed pedicellariæ present. Spines of the dorsal side single or, more rarely, in groups; tube-feet in 2-4 series III. *Forcipulata*

I. Order. PHANEROZONIA Sladen

Marginal plates well developed and usually conspicuous, forming a distinct, mostly vertical margin along the edge of disk and arms ; the oral and aboral side of disk and arms are thus as a rule distinctly demarcated from each other. As a rule the marginal plates are more or less covered by spines or granules, sometimes, however, only by soft skin, in which case the plates are less distinct. Papulæ with a few exceptions (some Linckiidae) confined to the aboral side (more rarely also between the marginal plates). The aboral side covered with paxillæ or scattered spines, or it may be wholly naked. Pedicellariæ, where present, of the simple spiniform or pectinate or valvate type, never of the crossed type ; they are found on the plates, never attached to the skin by means of a soft stalk. Tube-feet always in two series. With the exception of some species of *Luidia*, normally 5-rayed.

The numerous forms of this, especially in tropical seas richly represented, order of sea-stars are divided in three suborders.

Key to the suborders of the Phanerozonia.

1. Tube-feet pointed, without a sucking disk. Aboral side of disk and arms usually covered with paxillæ I. *Paxillosa*
 Tube-feet provided with a sucking disk 2
2. Upper and lower marginal plates alternating. Pedicellariæ simple, spiniform, or pectiniform. Aboral side covered with paxillæ II. *Notomyota*
 Upper and lower marginal plates not alternating. Pedicellariæ, when present, valvate or, more rarely, simple ; in the latter case one or two large, recurved, hyaline spines on jaws. Aboral side with paxillæ, spines, or naked III. *Valvata*

1. Suborder. **Paxillosa** Perrier.

Dorsal side usually covered with paxillæ, often with a central, conical prominence. Marginal plates covered with spines of varying length ; upper and lower marginals as a rule opposite one another, not alternating. Simple, spiniform pedicellariæ may occur. Tube-feet pointed, without a sucking disk. No paired dorsal arm-muscles.

Three families are represented in the British seas.

Key to the families of the Paxillosa.

1. Cribriform organs¹ developed between (some of or all) the marginal plates ; ampullæ single I. *Porcellanasteridæ*
 No cribriform organs ; ampullæ double 2
2. Upper marginal plates well developed ; papulæ simple ; mostly only a single pair of genital organs at the base of each ray
 II. *Astropectinidæ*
 Upper marginal plates undeveloped (replaced by paxillæ) ; papulæ bush-shaped. A series of genital organs along each side of the ray, nearly to the end III. *Luidiidæ*

I. Family PORCELLANASTERIDÆ²

Marginal plates very high, but relatively thin and lamelliform, naked or covered with rather thick membrane. Aboral side with paxillæ or single spinelets. Interradial areas on the oral side more or less extensive, paved with squamiform plates, covered with delicate membrane, and sometimes bearing isolated spinelets or fimbriated channels (or "fascioles"). Cribriform organs present. Adambulacral plates large, with a simple marginal armature, uniserially disposed. No intestine or intestinal cæca ; no anus. Tube-feet pointed, ampullæ simple.

Only one genus and species, *Ctenodiscus crispatus*, has been found in the British seas. There is, however, good reason to expect that the rich fauna of deep-sea Porcellanasteridæ known from the region between the Bay of Biscay, the Azores and the Cape Verde Islands will prove to be well represented also in the deeper waters off Ireland, and it seems therefore desirable to include these forms in the key.

Key to the North-East Atlantic genera of Porcellanasteridæ.

1. Cribriform organs between all the marginals ; fimbriated channels (fascioles) present in the oral interradian areas
 I. *Ctenodiscus* Müller and Troschel
 Cribriform organs localised, not between all the marginals. No fimbriated channels on oral interradian areas 2
2. Lower marginal plates rudimentary or absent ; one cribriform organ, in the middle in each interradius. *Albatrossaster* Ludwig
 Both upper and lower marginals well developed 3

¹ See p. 44.

² Possibly it might be more correct to make the Porcellanasterids a separate suborder, like the Notomyota.

3. Oral interradial areas covered with spiniform granules. Adambulacral plates with papilliform spinelets on the outer part; terminal plate very small and inconspicuous, unarmed; fourteen eribriform organs *Thoracaster* Sladen
- Oral interradial plates usually naked; adambulacral plates with a single series of spines on furrow margin only. Terminal plate large, with conspicuous spines; 1-11 eribriform organs 4
4. Dorsal side only with simple spines; a conical elongation in the middle. Oral interradial plates not imbricated; ambulacral furrow wide; 1 eribriform organ *Porcellanaster* Wyv. Thomson
- Dorsal side with paxillæ, at most with a slight peak in the middle. Oral interradial plates imbricated and arranged in columns; ambulacral furrow narrow; 3 or more eribriform organs . 5
5. A series of robust spines along the median line of rays
- Styracaster* Sladen
- No spines on middle line of rays *Hyphalaster* Sladen

Of the genus *Porcellanaster* Wyv. Thomson (Syn. *Caulaster* Perrier) four species have been found in the said area, viz. *P. (Caulaster) Sladeni* Perrier (32° 38' N.; 12° 9' W., 1435 m.); *P. (Caulaster) pedunculatus* Perrier (42° 50' N.; 2° 57' W., 2020 m.); *P. inermis* Perrier (38° N. 27° W.; 16° N. 20° W., 2995-3200 m.), and *P. granulatus* Perrier (19°-16° N.; 20° W., 2320-3200 m.). Of the genus *Styracaster* Sladen four species, viz. *St. spinosus* Perrier (40° N. 18° W.; 38° N. 27° W., 2995-4360 m.); *St. Edwardsi* Perrier (15° 48' N.; 22° 43' W., 3655 m.); *St. horridus* Sladen (44° N. 10° W.; 31° N. 24° W.; 2° S. 14° W., 4300-5400 m.), and *St. elongatus* Koehler (40° N. 18° W.; 38° N. 23° W.; 37° N. 20° W., 4020-5360 m.). Of the genus *Hyphalaster* Sladen three species, viz. *H. Parfaiti* Perrier (Syn. *H. Antonii* Perrier) 46° N. 9° W.; 38° N. 27° W.; 16° N. 24° W., 2995-5430 m.); *H. fortis* Koehler (40° N. 18° W.; 16° N. 24° W., 3890-4360 m.), and *H. gracilis* Koehler (31° N. 24° W., 5413 m.). Of the genus *Thoracaster* Sladen one species, *Th. cylindratus* Sladen (Syn. *Pseudaster cordifer* Perrier) (off Portugal, Josephine Bank, Canaries, 4275-4392 m.), and of the genus *Albatrossaster* Ludwig one species, *A. Richardi* Koehler (12° N. 33° W., 6035 m.).

For descriptions of all these species reference must be made to the works of Sladen ("Challenger"), Perrier ("Talisman"), and Koehler (Monaco, Fasc. xxxiv.).

The genus *Ctenodiscus* has recently been maintained rather to belong to the family *Goniopectinidae*, which is distinguished from the true *Porcellanasterids* mainly by having eribriform organs between all the marginal plates and by having fimbriated or fasciolar channels between the oral interradial

plates. It is also regarded as representing a separate subfamily, *Ctenodiscinae*. It may, however, suffice here just to mention these facts, otherwise leaving the genus in the family Porcellanasteridae to which it has usually been referred and to which it is, at any rate, closely related.

1. *Ctenodiscus* Müller and Troschel.

General form stellate. Aboral side covered with paxillæ. Both upper and lower marginal plates naked, but each with a single, conical, rather strong spine near the upper margin. Cribriform organs between all the marginal plates, but covered by a web of papillæ along the edge of the plates; they continue as simple channels, covered by similar webs, over the oral interradial area and between the adambulacral plates. No anal opening.

Only one species in the British seas, and, indeed, in all northern seas.

1. *Ctenodiscus crispatus* (Retzius). (Fig. 30.)

(Syn. *Ctenodiscus corniculatus* (Linck).)

Disk flat, underside somewhat convex. Arms 5 (exceptionally 6 or 4), varying very considerably in length; $R=1.6-3 r$.

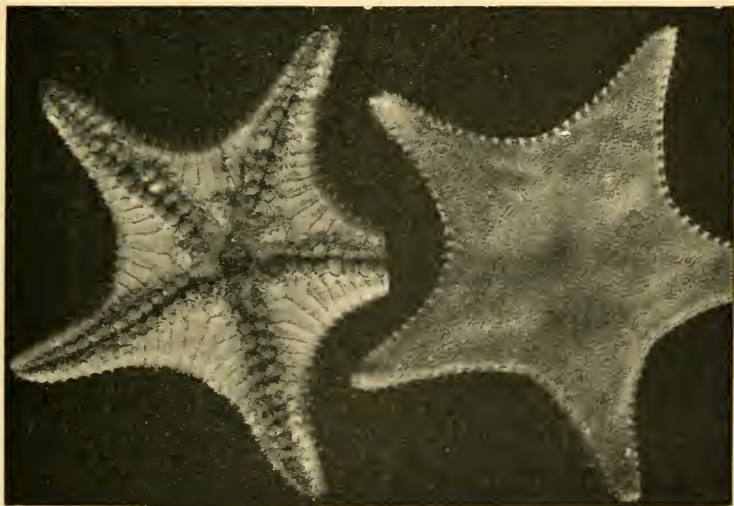


FIG. 30.—*Ctenodiscus crispatus*. From the oral and dorsal side. Nat. size.

Marginal, oral interradial and adambulacral plates covered by a thin, soft skin. Adambulacral plates with 3-5 short, skin-covered spines, the two middle ones the larger. Ambulacral

furrow wide. Colour of living specimens yellowish. Size up to ca. 5 cm. R.

The species appears to reach its full size in the course of three years. Development unknown, but as it has large, yolky eggs it is likely to have direct development, without a pelagic larval stage. It lives on a soft, muddy bottom and fills its stomach with mud, largely, at any rate, by means of the ciliary currents produced by the cribriform organs and the ciliated channels between the oral interradiial plates. The fine particles of mud thus brought towards the mouth are imbedded in mucus so as to form strings.

In British seas this species has been found only in the cold area of the Faroe Channel, 560-1135 m. ("Porcupine"). It is an arctic species, probably circumpolar; on the Scandinavian coast it is also found at relatively high temperatures, up to 10° C. (not found S. of the Trondhjemsfjord). It occurs at the N. coast of Iceland, at Greenland, and at the East Coast of N. America a little beyond Cape Cod. In the Pacific it extends to Japan and along the W. coast of America down to Chile. The bathymetrical distribution is ca. 10-1860 m. and probably even more, but it appears to have its main distribution in depths of ca. 50-600 m.

II. Family ASTROPECTINIDÆ

Upper and lower marginal plates well developed, thick, more or less covered with spines or grains. Aboral side covered with papillæ. Oral interradiial areas covered with spines. No cribriform organs, but often with distinct marginal "fascioles", which are never webbed. Intestine, generally also intestinal cæca present; anus present or absent. Tube-feet pointed; ampullæ double; papulæ simple. Genital organs mostly confined to base of ray.

Six genera of this family are represented in the British seas. In addition there is some possibility that two more genera will also be found to occur there, viz. *Tethyaster* Sladen and *Dytaster* Sladen (Syn. *Crenaster* Perrier); these two are therefore also included in the key to the genera of Astropectinidæ, while not otherwise described here. Of *Tethyaster* only one species, *T. subinermis* (Philippi) (Syn. *Plutonaster subinermis*), occurs in European seas, known from the Bay of Biscay to Morocco and Liberia, and especially from the Mediterranean (60-300 m.). Of *Dytaster* no less than eight species have been recorded from the North-East Atlantic, viz. *Dytaster biserialis* Sladen (36° N. 23° W., 3645 m.; 40° N. 18° W., 4360 m.); *D. parvulus* Koehler (37° N. 20° W.,

4275 m.); *D. Agassizi* Perrier (Bay of Biscay, Azores, 3120-4360 m.); *D. intermedius* Perrier (Azores, 2870 m.); *D. rigidus* Perrier (Bay of Biscay, Azores, 4443-5005 m.); *D. (Crenaster) mollis* Perrier (Azores, 2995 m.); *D. (Crenaster) semispinosus* Perrier (44° N. 15° W., 5005 m.); *D. (Crenaster) spinulosus* Perrier (44° N. 19° W., 4255 m.). For descriptions and figures of all these species reference must be made to the works of Sladen (Asteroidea, "Challenger"), Kochler (Monaco, Fasc. xxxiv.), and Perrier (*Échinodermes du "Travailleur" et du "Talisman"*).

Key to the genera of Astropectinidæ known from or likely to occur in the British seas.

1. Upper marginal plates much smaller than the lower ones; both covered with small grains, without any larger spines. Small form 6. *Leptychaster* Smith
- Upper and lower marginal plates of about equal size; more or less conspicuous spines on lower, often also on upper marginal plates 2
2. Oral interradial area very large, with 6-7 series of plates; lower marginals with a series of large spines, upper marginals without any. Madreporite large, naked. Large form

Tethyaster Sladen

- Oral interradial area very small, or of medium size, with at most 3-4 series of plates 3
3. Oral interradial area very small, interradial plates not continuing beyond base of arm; adambulacral plates therefore joining lower marginals in almost the whole length of arm; spines on lower marginals forming a prominent fringe all round body and arms 1. *Astropecten* Linck

Oral interradial area of medium size, the inner (adradial) series of interradial plates generally extending to about the middle of arm, separating adambulacrals from lower marginals. Spines of lower marginals not forming a prominent fringe round body and arms 4

4. Upper marginals thin, confined to side wall of ray; oral interradial plates often with peculiar, subvalvular pedicellariæ (Fig. 31). Madreporite very large, covered with paxillæ

Dytaster Sladen

Upper marginals not thin and confined to side wall of ray; no subvalvular pedicellariæ on oral interradial area. Madreporite not very large 5

5. Madreporite covered with paxillæ 4. *Plutonaster* Sladen
- Madreporite not covered with paxillæ 6

6. Marginal plates distinctly tumid; side of arm not very high. Dorsal side of arm, between marginals, very narrow

5. *Persephonaster* Alcock

Marginal plates not tumid ; side of arm very high. Dorsal side of arm, between marginals, not very narrow 7

7. Adambulacra strongly projecting into the ambulacral furrow ; median furrow spine prolonged

3. *Bathybiaster* Danielssen and Koren

Adambulacra less strongly projecting into the ambulacral furrow ; median furrow spine not prolonged

2. *Psilaster* Sladen

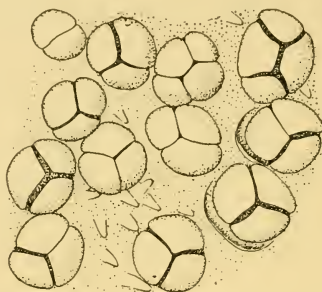


FIG. 31.—Pedicellariæ from oral interradial area of *Dytaster rigidus*.
× 8.

1. *Astropecten* Linck.

Disk fairly large ; arms low, broad, of medium length. Upper marginal plates with fine grains and, sometimes, with one or more larger, erect, conical spines ; lower marginal plates with flat spines, which form a distinct fringe all round the edge of disk and arms. Oral interradial areas very small, with only 1-3 series of interradial plates which do not continue beyond the basal part of the arms, thus the adambulacral and lower marginal plates join each other in almost the whole length of the arm. Madreporite naked. No pedicellariæ.

A great number of species, especially from tropical seas, belong to this genus. In British seas only two species have been found. Four more species occur in the Mediterranean, two of which, viz. *A. aranciæ* (Linn.) (Syn. *A. aurantiæ* Tiedemann¹) and *A. bispinosus* Otto, also have been found in the Atlantic, the former at the Canaries, the latter at the Azores. *A. aranciæ* has also been recorded (by Perrier) from the Bay of Biscay, but the identification has been found to be incorrect. (This is certainly also the case with a record of *Astropecten*

¹ The *Asterias aurantiæ* (Linn.), recorded from the Clyde sea area (Chumley), is certainly not the *Astropecten aranciæ* ; one may perhaps suggest it to be *Stichastrella rosea*.

Johnstoni Delle Chiaje (Syn. *A. squamatus* Müll. and Troschel) from the North Sea, off Föhr.) Another species, *A. hermatophilus* Sladen, is known only from the Azores (ca. 800 m.). While there may perhaps be a possibility that the latter may occur also as far north as the British seas, it is hardly to be expected that any of the other species will be found there. It may therefore suffice in regard to these forms to refer to the descriptions and keys of the European species of *Astropecten* given by Koehler in *Faune de France*, i. *Échinodermes* (1921); and *Les Échinodermes d'Europe*, i. 1924, p. 187. *A. hermatophilus* is distinguished from *irregularis*, to which it has otherwise great resemblance, by its marginal spines, only three on each lower marginal, the upper one of which is the largest, while in *irregularis*, with 4-5 marginal spines, the second or third from above is the largest, one or two smaller spines being found above, adorally to, the largest.

Key to the species of Astropecten of the British seas.

- | | |
|---|----------------------------------|
| Oral interradiar areas with only one series of plates ; lower marginals simply flattened | 1. <i>A. irregularis</i> (Penn.) |
| Oral interradiar areas with 2-3 series of plates ; lower marginals elevated, wedge-shaped | 2. <i>A. sphenoplax</i> Bell |

1. *Astropecten irregularis* (Pennant). (Fig. 32.)

(Syn. *Astropecten Mülleri* Müll. and Troschel ; *A. acicularis* Norman ; *A. ibericus* Perrier.)

Upper marginal plates generally with a larger, conical spine, especially in the outer part of arms. Lower marginals flattened, rectangular, at their upper end with 4-5 large marginal spines in an oblique series that passes downwards along the outer edge of the plate ; the second-third from above is the largest, one or two smaller ones being found adorally above the largest, the plates otherwise covered with small flattened, somewhat scale-like spines. Upper and lower marginals corresponding exactly to each other. Oral interradiar areas with a single series of plates (the ventrolateral plates), mostly 4-7 in number. In larger specimens there may be indications also of a second (outer) series. Adambulacra with 3 equal-sized furrow spines. No pedicellariæ. Colour reddish-violet or yellowish, with or without purple marks. $R = 3.5-4.5 r$. Grows to a size of ca. 10 cm. R.

The great variation in the development of spines on the upper marginal plates has caused the establishment of some "species" which cannot, however, rank higher than varieties, viz. var.

pentacanthus (D. Ch.), entirely lacking the large spine on the upper marginals, and var. *serratus* (Müller and Troschel), which has several larger spines (3-5) on the upper marginals.

The larva is a Bipinnaria with short arms¹; it has no Brachiolaria stage (Fig. 28, 3).

It is a very voracious species, feeding mainly on various molluscs, crustaceans, echinoderms, annelids, and appears to be a noticeable competitor for the food of the plaice. The animals that make its food are swallowed whole. Even small fishes it

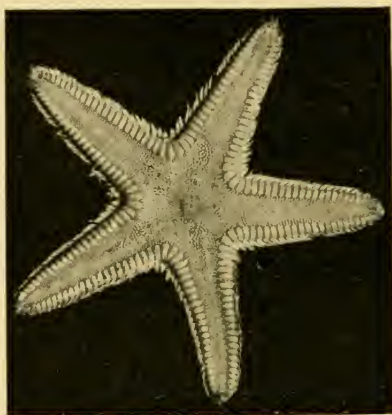


FIG. 32.—*Astropecten irregularis*. Dorsal side. Nat. size.
(From *Danmark's Fauna*.)

eats, though it is probably able to catch only such specimens as are not in a healthy condition and therefore unable to escape.² It prefers a sandy bottom, in which it buries itself so as to lie concealed.

Common all round the British coasts. It is distributed from Lofoten on the Norwegian coast to Morocco, probably even to the Cape Verde Islands. In the Mediterranean the var. *pentacanthus* alone occurs. Bathymetrical distribution, ca. 10-1000 m.

¹ Figures of the younger stages of the *Astropecten irregularis* larva are given in H. E. Newth's paper, "The early development of *Astropecten irregularis*", *Quart. Journ. Micr. Sc.* **69**, 1925, Pl. 41.

² The author has observed that a specimen of *Amphiura Chiajei*, which was removed from the stomach of an *Astropecten irregularis* eighteen hours after this latter was caught, was still alive, though the skin and the tube-feet had been digested. It was still alive after two days, and had begun to regenerate its tube-feet. Probably it would have recovered completely if the experiment had not been discontinued.

2. *Astropecten sphenoplax* Bell.¹

Upper marginal plates mostly with a larger, conical spine. Lower marginals with an oblique series of ca. 10 long, slender spines situated on a raised ridge, which gives the whole plate a conspicuous wedge-shape. The surface of the marginals otherwise closely covered with very fine, not flattened or scale-like, spinelets. Lower marginals not regularly rectangular, but curving adorally in their lower part. In the proximal part of arms upper and lower marginals do not quite correspond, the lower being somewhat adorally displaced, the plates of the two series thus to some degree alternating. Oral interradi al areas with 2-3 series of ventro-lateral plates, the inner series with 4-6 plates. Adambulacral plates with 3 furrow spines. No pedicellariæ. Colour in life unknown. $R = 4.5 r$. Largest size recorded 52 mm. R.

Biology and development unknown.

This appears to be a rare species, having been found only off Blacksod Bay, Co. (ca. 900 m., "Fingal"), in the Bay of Biscay (828 m.), and off the Azores (1187 m., "Princesse Alice").

2. *Psilaster* Sladen.

Disk rather small ; arms high, with almost vertical sides, long, narrow and pointed. Marginal plates high and narrow, covered with fine grains, the lower with single larger spines, which lie flat and do not form a marginal fringe. Oral interradi al areas fairly large, with 3-4 series of small plates, continuing to about the middle of arm, separating the adambulacral from the lower marginal plates. Madreporite naked. No pedicellariæ.

Only one species in European seas.

1. *Psilaster andromeda* (Müller and Troschel). (Fig. 33.)

(Syn. *Astropecten andromeda* Müll. and Trosch.)

Marginal plates only partly covered with fine grains or small, scale-like spines, these being in the main confined to the edge of the plates, leaving a median part naked. The larger spines on the lower marginals in a vertical series along the outer edge. Adambulacral plates somewhat projecting in the furrow, carrying

¹ No very good figure exists of this species. The present author having had the opportunity of examining only one poorly preserved specimen, must refer to the figures given on Pl. XI in Bell's *Catalogue* ; the Fig. 2 on that plate gives a rather good impression of the peculiar wedge-shape of the lower marginals.

6-8 furrow spines of about equal size. Paxillæ of the dorsal side small, arranged in fairly regular transverse series in the basal part of the arms. $R = \text{ca. } 4.5, 5 r$.

In life, colour pale pink or whitish. The skin is somewhat gelatinous; the living specimens, therefore, are as a rule rather slimy. Grows to a size of ca. 10 cm. R ; it appears to reach full size in the course of four years. Its food consists of molluscs, especially small mussels, echinoderms (young spatangoids),



FIG. 33.—*Psilaster andromeda*. Nat. size.
(From *Danmark's Fauna*.)

foraminifera, etc. It prefers a soft, muddy bottom. Development unknown, but its large, yolky eggs indicate direct development, without a pelagic larval stage.

Common in deeper waters off the W. coast of Ireland, especially in depths of ca. 700-900 m. It is distributed from the Murman Coast to the Cape Verde Islands and the Azores. Also at the American Coast from Davis Strait to 38°N .¹ Bathymetrical distribution, ca. 70-1850 m. (Exceptionally found at a depth as small as 19 m.).

3. *Bathybiaster* Dan. and Koren.

Very much like *Psilaster*, from which it differs mainly in the adambulacral spines projecting into the wide ambulacral furrow, the median furrow spine being considerably longer than the rest of them (Fig. 34).

¹ The American form has been described as a separate species, *Psilaster floræ* Verrill, but can hardly be distinguished from the European form.

This form is so very closely related to *Psilaster* that it may well be regarded as doubtful whether it really deserves to rank as a separate genus or perhaps rather should be united with *Psilaster*.

The elongate median furrow spine is very brittle and very often is lost, more or less completely, in preserved specimens. Sometimes the broken point hangs, by means of the enclosing skin, as a small flag on the basal part of the spine. Such broken spines were at first mistaken as representing a special structure peculiar to this sea-star, designated as the "vexillum", and gave rise to the species name *vexillifer*. It has also been wrongly interpreted as a kind of pedicellaria.

Only one species found in the North Atlantic.



FIG. 34.—Side view of ambulacral plate, with the furrow spines, of *Bathybiaster vexillifer*. (From Th. Mortensen, *N.E. Greenland Echinoderms.*) $\times 22$.

1. *Bathybiaster vexillifer* (Wyv. Thomson). (Fig. 35.)

(Syn. *Archaster vexillifer* Wyv. Thomson; *Archaster robustus* Verrill; *Bathybiaster pallidus* Dan. and Koren; *Bathybiaster robustus* (Verrill); *Ilyaster mirabilis* Dan. and Koren; *Phoxaster pumilus* Sladen.)

The sides of the arms vertical, formed by the very high and narrow marginal plates, which are wholly covered by short, flat, scale-like spines. Generally there is a short conical spine at the upper edge of the upper marginal plates, often wanting, however, in those at the base of the arms and along the interradii. The lower marginal plates generally have a somewhat longer and more slender spine at the lower edge, and often two-three more, placed irregularly higher up on the plate. Adambulacral plates rather strongly projecting into the wide ambulacral groove, the triangular projection being emphasised through the enlarged median spine. Paxillæ of the dorsal side rather large, more or less distinctly arranged in transverse series along the sides in the basal part of rays. $R = \text{ca. } 4\text{--}6\ r$. Colour in life pale yellow or pale rose.

Grows to a size of ca. 13 cm. R. The young specimens have a distinct dorsal conical prominence. Biology and development unknown.

In the British seas this species has been found in the Faroe Channel, the cold area, 344 m. ("Porcupine"); further at 50° 22' N., 11° 44' W., 1797 m., and 57° 41' N., 11° 48' W., 1853 m. ("Michael Sars"). It appears to be distributed all over the North Atlantic, both on the European and American side, up to Umanak Fjord on the west coast of Greenland. Further, it appears to occur all over the Norwegian sea (the cold area), from the Faroe Channel to Spitzbergen and east Greenland. Known bathymetrical distribution, 223-2222 m.

It has been maintained recently (Grieg) that the form occur-

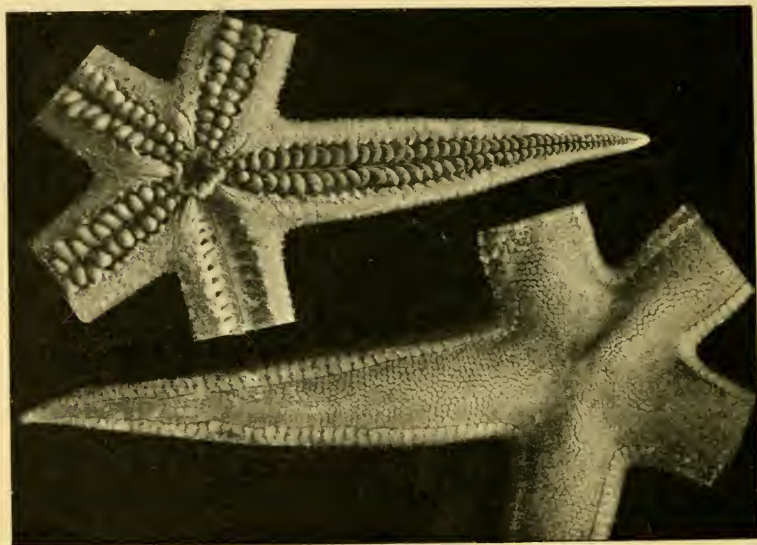


FIG. 35.—*Bathybiaster vexillifer*, oral and aboral side. Somewhat reduced in size.

ring in the cold area, the true *B. vexillifer*, is to be distinguished as separate from the form of the warm area, *B. robustus* Verrill. Besides a slight, not quite constant difference in the number of spines on the marginal plates, and a somewhat more vertical position of the marginal plates of the basal part of the rays in *B. robustus*, the only real difference is stated to be this, that the skeletal plates of the dorsal side are stellate, over-lapping, in the cold-water form, round or polygonal, not over-lapping, in the warm-water form. This character, however, the present author finds to be also inconstant, and thus there is not a single reliable character by which to distinguish the two forms. At

most we can speak of a warm-water and a cold-water variety of one and the same species.

4. *Plutonaster* Sladen.

Disk large ; arms narrow, low, of medium length. Marginal plates rather thick, not very high, covered with small grain-like spines, among which may occur some large, conical spines. Oral interradiat areas large with several series of plates, the inner series continuing to about the middle of the arm. Madreporite covered by paxillæ. No pedicellariæ.

One species is known to occur in the British seas, but three or four more may be expected to occur there also, viz. *Plutonaster rigidus* Sladen (Syn. *Pl. granulosus* Perr.), known from the Bay of Biscay to Madeira and the Azores, 1165-1900 m. ; *Pl. notatus* Sladen, from off the Azores, ca. 1500-2180 m. ; *Pl. abbreviatus* Sladen, from off the Azores, 1800 m., and *Pl. marginatus* Sladen, from off the Cape Verdes and Ascension (777-1700 m.). Descriptions and figures of these species are given in the "Challenger" Asteroidea, as also a key to the species of the genus *Plutonaster* (p. 82), to which the reader may be referred.¹

1. *Plutonaster bifrons* (Wyv. Thomson.) (Fig. 36.)

(Syn. *Archaster bifrons* Wyv. Thomson.)

Both upper and lower marginal plates each with a prominent conical spine ; there is thus a double fringe all round the disk and arms. The marginal plates otherwise covered with very minute spines. Adambulacral plates with a comb of 8-10 equal-sized furrow spines, outside which there is a single large, conical spine. Plates of the oral interradiat areas covered with minute spines and a single large spine. Paxillæ of the dorsal side rather fine, in somewhat indistinct transverse series in the basal part of rays along the sides. $R = \text{ca. } 3.2-5r$. Colour in life creamy yellow. Grows to a very considerable size, up to 20 cm. R. Biology and development unknown.

The presence of a large spine on both upper and lower

¹ Also Koehler (*Resultats Camp. Scientif.* . . . Monaco, Fasc. xxxiv.) gives figures of these species. One more species, *Plutonaster Edwardsi* Perrier, has been recorded from 39° 33' N., 12° 11' W., 2590-2660 m. ("Travailleur"). The description (Perrier's *Échinodermes du "Travailleur" et du "Talisman"*, p. 315) is, however, incomplete and without figures, the species therefore scarcely recognisable.

marginal plates distinguishes this species from all the other species of the genus *Plutonaster*.

In British seas this species appears to be fairly common in

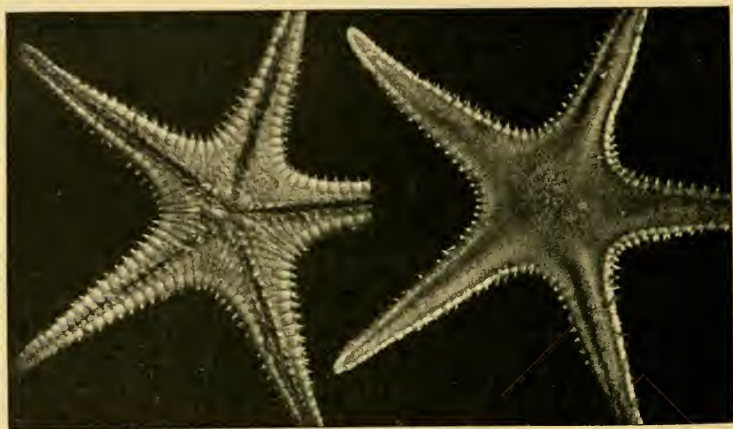


FIG. 36.—*Plutonaster bifrons*, oral and aboral side. Somewhat reduced in size.

deep water off the Irish coasts, especially in depths beyond 900 m. It is elsewhere distributed from the Faroe Channel to about the Cape Verde Islands; occurs also in the Mediterranean. Known bathymetrical distribution, ca. 100-2500 m.

5. *Persephonaster* Alcock.

(Syn. *Psilasteropsis* W. K. Fisher.)

Disk rather small; arms low, tapering to a point. Marginal plates massive, somewhat tumid; lower marginals with an oblique series of slender spines. Dorsal side of arms very narrow on account of the encroaching of the marginals. Oral inter-radial areas rather small; the interradiial plates extend about one-third the length of the ray. Madreporite naked; simple pedicellariæ may occur.

Only one species has been found in the British seas, but one more, viz. *Persephonaster humilis* (Koehler) (Syn. *Psilasteropsis humilis* Koehler), may be expected to occur there also. This latter species, known only from off the Azores, 845 m. ("Princesse Alice"), is very easily distinguished from *P. patagiatus* by having a large spine on the upper marginal plates.

1. *Persephonaster patagiatus* (Sladen). (Fig. 37.)

(Syn. *Psilaster patagiatus* Sladen ; *Psilasteropsis patagiatus* (Sladen).)

Upper marginal plates covered with minute, scale-like spines ; lower marginals with the same general covering, but with an oblique series of 3-5, or even as many as 10, long, slender, appressed spines along the outer edge. Adambulacral plates with a comb of ca. 10 slender spines (sometimes more, up to 17) ;

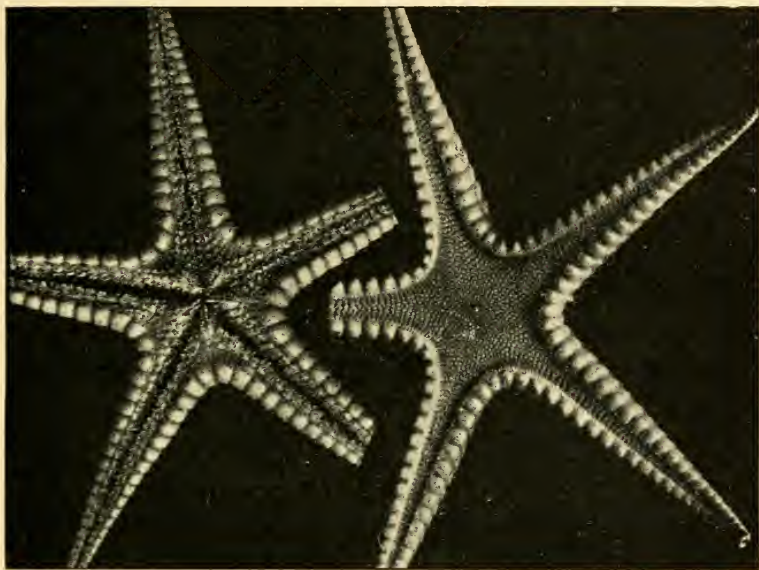


FIG. 37.—*Persephonaster patagiatus*, oral and aboral side. Slightly reduced in size.

outside these are found some smaller spines more or less distinctly arranged in two longitudinal series. The spines on the oral interradial plates, which are of the same general character as those on the adambulacral plates, may be grouped so as to form simple pedicellariæ. Also on the upper marginal plates there may be a kind of incipient pedicellariæ. Paxillæ of the dorsal side of arms fairly large, arranged in distinct transverse rows along the sides. Towards the point of the arms the upper marginal plates join in the middle line. Terminal plate rather long, apparently ending in a large, conical medial spine and a

pair of smaller lateral ones. $R = \text{ca. } 4.5 \text{ r.}$ Grows to a size of at least 10.5 cm. R . Colour in life rosy.

Biology and development unknown.

In British seas this species has been found at $51^{\circ} 15' \text{ N.}$, $12^{\circ} 17' \text{ W.}$, ca. 1200-1600 m. ("Helga"), and $57^{\circ} 41' \text{ N.}$, $11^{\circ} 48' \text{ W.}$, 1853 m. ("Michael Sars"). Otherwise it is distributed as far south as the Cape Verde Islands and the Azores. Known bathymetrical distribution, 1095-2165 m.

6. *Leptychaster* E. A. Smith.

(Syn. *Leptoptychaster* E. A. Smith.¹)

Disk fairly large; arms rather broad, low, with rounded sides. Marginal plates covered with grains alone, without any larger spines. Upper marginal plates much smaller than the lower ones. Oral interradiar area rather large. No pedicellariæ.

Only one species known from European seas.

1. *Leptychaster arcticus* (M. Sars). (Fig. 38.)

(Syn. *Astropecten arcticus* M. Sars.)

Adambulacral plates with 3-4 fairly long and slender furrow spines; outside these some other spines of decreasing size, not

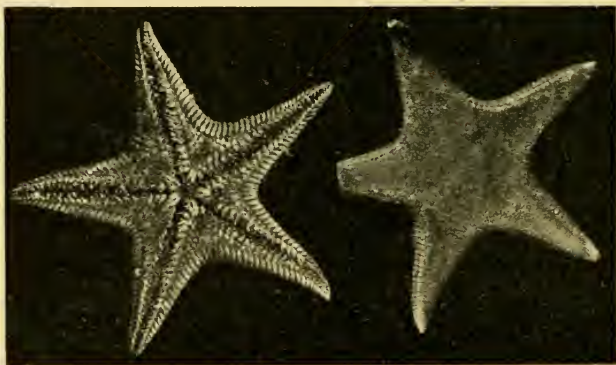


FIG. 38.—*Leptychaster arcticus*, oral and aboral side. Nat. size.

regularly arranged in series. Paxillæ of the dorsal side not distinctly arranged in transverse series. $R = \text{ca. } 2.3 \text{ r.}$ Colour in life orange or light reddish.

¹ This latter form of the name is etymologically the more correct and should, perhaps, be preferred.

It is a small form, scarcely reaching more than 30 mm. R. Biology and development unknown.

In British seas this species has been found in the Faroe Channel ("Porcupine") and S. of Ireland ($48^{\circ} 31' N.$, $10^{\circ} W.$). Elsewhere it has been found at the Scandinavian coasts from Finmark to Trondhjem Fjord on the coasts of Norway, as also at West Greenland and the American east coast, down to $38^{\circ} N.$ Further it occurs in the North Pacific from the Bering Sea down to northern Japan. It may then well be supposed to be circumpolar. Bathymetrical distribution ca. 40-1260 m.¹

III. Family LUIDIIDÆ

Upper marginal plates replaced by paxillæ; lower marginals well developed, covered with spines. Aboral side with paxillæ; oral interradial areas with spines. No cribriform organs; marginal fascioles never webbed. No intestine, intestinal cæca or anus. Tube-feet without sucking disks. Ampullæ double; papulæ bush-shaped. Genital organs in a series along each side of arm, almost to the end.

Only one genus in European seas.

1. *Luidia* Forbes.

Arms long and narrow; disk small, flat. Lower marginals very broad, with some large, projecting spines. Oral interradial areas small. Simple pedicellariæ may occur.

Only two species are found in British and European seas; a third species, *Luidia africana* Sladen, occurs on the N.W. coast of Morocco, but there is hardly any prospect of finding it as far north as the British seas. It is closely related to *L. Sarsi*, but grows to a larger size, ca. 20 cm. R.

The British species are both very fragile, especially *L. ciliaris*, and it is rather difficult to secure complete specimens; if it is grasped by one of its arms this almost instantaneously breaks off.² In good accordance herewith the regenerating power is very great, and most specimens show one or more arms in regeneration.

¹ The statement (Bell, *Catalogue Brit. Echinoderms*, p. 66) that it was taken at a depth of 1312 fathoms (2470 m.) in the Faroe Channel ("Porcupine", St. 82) is simply a misprint for 312 fathoms.

² An amusing account by E. Forbes of his vain efforts to secure a fine specimen of "*Luidia fragilissima*" is quoted in G. H. Lewes's *Sea-side Studies*, 2nd ed., 1860, p. 255.

The *larva* (Fig. 28, 1, 2) is rather large, with the anterior part of the body greatly prolonged, all the arms being placed close together in the posterior part and around the mouth. It appears to be a special character of these larvæ that the left postero-lateral arm is distinctly shorter than the right. Furthermore, the *Luidia* larvæ differ from other Asteroid larvæ in swimming not only by means of the ciliated bands, but also by actively moving the two median processes that terminate the elongated anterior part of the body. When the young sea-star is ready for living by itself, the whole larval body is thrown off; the latter may still go on swimming about for some time. In other Asteroid larvæ the larval body is not thrown off but completely absorbed by the young sea-star. The young sea-star hanging on the larva is red, the larva otherwise colourless. Apparently there is no other character than the size by which to distinguish the two species of *Luidia* larvæ, the fully-formed larva of *L. Sarsi* being ca. 25-35 mm. long, the larva of *L. ciliaris* only ca. 7 mm.; however, this is not very certain, the larva of the latter species having not yet been very carefully studied. As soon as the hydrocoel has formed the first rudiments of the radial water-vessels, the two larvæ are easily distinguished, the larva of *L. Sarsi* having only 5, that of *L. ciliaris* 7, radial pouches.

The *Luidia Sarsi* larva was the first echinoderm larva to be discovered, viz. by Michael Sars, who in 1835 described it under the name of *Bipinnaria asterigera*, without, however, suspecting its being an Asteroid larva. Only many years later Ludwig recognised it as the larva of *Luidia Sarsi*.

The number of eggs that an adult *Luidia ciliaris* produces yearly is immensely great, at least ca. 200 millions. As this species is, however, not represented by any great number of individuals, even where it is most common (e.g. the Channel), this necessarily means that an immense number of the eggs and larvæ must perish.

The rather numerous species known of the genus *Luidia* are subdivided in several subgenera. The two European species belong to the subgenus *Hemicnemis* Müller and Troschel.

Key to the British species of Luidia.

5 arms ; lower marginals with 3, rarely 4, spines	1. <i>L. Sarsi</i>
7 ,, ,, ,, ,, 4 or 5 spines	2. <i>L. ciliaris</i>

1. *Luidia Sarsi* Düben and Koren. (Fig. 39, *b*.)

(Syn. *Luidia paucispina* v. Marenz. ; *Astrella simplex* Perrier.)

Five gently tapering arms. Four transverse series of lateral paxillæ corresponding to each two marginal paxillæ. Across the dorsal side of arm ca. 15-20 median paxillæ. Lower marginals with 3, rarely 4, spines. Papulæ with few lobes ; they are lacking in the middle of the disk and along the middle of the arms. Pedicellariæ, generally only bivalved, are found on the under side. $R = 6-10\ r$. Colour reddish-brown, with darker transverse bands along the sides of rays. Grows to a size of ca. 17 cm. R.

It is a very voracious animal, feeding mainly on echinoderms,

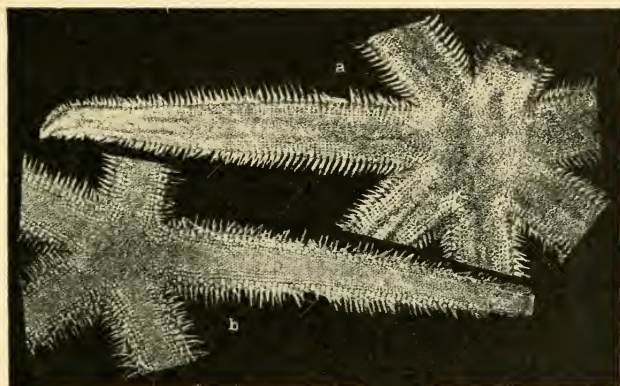


FIG. 39.—a, *Luidia ciliaris* ; b, *L. Sarsi*. Somewhat reduced. (After Koehler ; from *Danmark's Fauna*.)

especially brittle-stars ; but polychæta, molluscs, and crustaceans are also often found in its stomach contents. It seems to prefer a muddy bottom. The breeding season is mainly in winter, the larvæ being found in September-May, apparently in greatest numbers about December. The larvæ may sometimes occur in great abundance.

In British seas this species is distributed probably all round the coasts, at least from the Eddystone grounds round the west and north coasts down to the southern parts of the North Sea. Otherwise it occurs from the Trondhjemsfjord on the Norwegian coast down to the Cape Verde Islands ; occurs also in the Mediterranean. It is recorded from depths of ca. 10-1300 m., but appears to be more rare beyond depths of ca. 600 m.

2. *Luidia ciliaris* (Philippi). (Fig. 39, a.)

(Syn. *Luidia fragilissima* Forbes; *L. Savignyi* Müller and Troschel.)

Seven arms, which taper only in the outer part. Three transverse series of lateral papillæ correspond to each two marginal paxillæ. Across the dorsal side of arm ca. 10 median paxillæ. Lower marginals with 4-5 spines. Papulæ many-lobed, lacking only in the outer part of arms. Bivalve pedicellariæ on the marginal plates, or trivalve (sometimes also bivalve), on the ventro-lateral plates; more rarely both sorts of pedicellariæ occur. $R=7.8r$. Colour red. It is a magnificent large sea-star, which grows to a size of ca. 30 cm. R.

It is a very voracious species, the food consisting mainly of various kinds of echinoderms—*Ophiothrix*, *Spatangus purpureus*, *Echinocardium*, *Asterias*, *Thyone*, *Cucumaria elongata*, etc. More rarely it devours mussels (*Pecten*). Nothing is known to feed on this species. It seems to prefer a sandy bottom. The breeding season is (on the English south coast) in summer-time; in the Mediterranean, November-January.

In the British seas it occurs from off the south coast round west to the Shetland Islands, but is not known farther down than off Yorkshire on the North Sea coasts. Otherwise it is distributed from the Faroe Islands to the Cape Verde Islands and the Mediterranean. It does not appear to occur on the Scandinavian coasts. Bathymetrical distribution, 4-ca. 400 m.

The specimens of *Luidia ciliaris* from the British seas are stated to differ from those of the Mediterranean in having only trivalve pedicellariæ, while the latter have as a rule only bivalve pedicellariæ. Because of this difference Ludwig made the British form of this species a separate variety, the var. *Normani*. Specimens with both kinds of pedicellariæ were, however, afterwards found in the Mediterranean, just as both sorts may be found in British specimens. There is therefore no sufficient reason for maintaining the var. *Normani* which was also dropped by Ludwig himself, but has been readopted by some recent authors.

2. Suborder. **Notomyota** Ludwig.

Dorsal side covered with paxillæ or spines. Marginal plates alternating, covered with spines. Pedicellariæ simple or pectinate, rarely bivalvate. Tube-feet with a small sucking disk. A pair of mostly strong dorsal muscles in each arm.

The alternating arrangement of the marginal plates make the arms more flexible ; this fact, combined with the existence of strong dorsal arm muscles, might lead to the suggestion that these sea-stars may, perhaps, be able to make swimming movements. There are, however, no observations to support such a suggestion.

Only one family belongs to this suborder.

I. Family BENTHOPECTINIDÆ

This family is distinguished by the characters of the suborder as well as by having the papulæ confined to a limited, often specialised, area, the " papularium ", at base of the rays and adjacent portion of the disk (or the whole disk). Intestine, intestinal cæca, and anus present.

Two genera represented in British seas, but one more, *Pectinaster* Perrier, may prove to occur there also, the species *Pectinaster Filholi* Perrier being known from the Azores to Cape Verde Islands, ca. 1250-2330 m. (" Talisman "). This genus, therefore, is included in the following key :

Key to the genera of Benthopectinidæ known from or likely to occur in the British seas.

1. A prominent odd interradial marginal plate, the upper usually with a very prominent spine 2. *Benthopecten* Verrill
- No odd interradial marginal plate 2
2. Pectinate pedicellariæ on the oral intermediate plates, on the marginal plates, and also on the dorsal side

Pectinaster Perrier

Pedicellariæ, when present, two-jawed and occurring only on the adambulacral and upper marginal plates

1. *Pontaster* Sladen

1. *Pontaster* Sladen.

Disk rather small, arms long, pointed ; dorsal side with paxillæ. Marginal plates small, each with a large spine. No odd interradial marginal plate. Adambulacral plates with a comb of fine furrow spines and 1-3 spines outside these. Pedicellariæ, when present, two-jawed, mainly on the adambulacral plates, but sometimes also on upper marginal plates.

Only one species, *P. tenuispinus* (Düb. and Kor.), known to occur in British seas, but another species, *Pontaster venustus* Sladen, known from the Bay of Biscay and between the Azores and Madeira (1165-4000 m.), may be expected to occur also in British seas. It is distinguished from *P. tenuispinus* by having only one larger spine on the adambulacrals outside the furrow spines ;

the two upper marginal plates in the middle of the interradii without a larger spine ; no pedicellariæ.

A third species, *Pontaster perplexus* Perrier, found near the Cape Verde Islands (ca. 1300-2320 m., "Talisman"), is stated to be intermediate between *tenuispinus* and *venustus*, and may perhaps not be a separate species.

1. *Pontaster tenuispinus* (Düben and Koren). (Fig. 40.)

(Syn. *Astropecten tenuispinus* Düb. and Kor., *Archaster tenuispinus* (Düb. and Kor.), *Pontaster hebitus* Sladen, *P. limbatus* Sladen, *P. Marionis* Perrier.)

Paxillæ of dorsal side small, often with a somewhat longer spine in the middle, especially in the outer part of the arms.

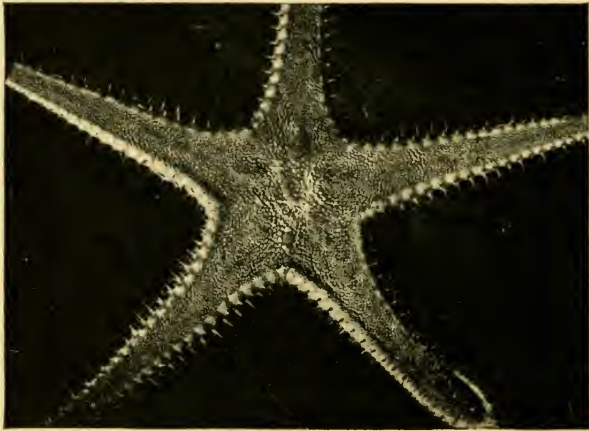


FIG. 40.—*Pontaster tenuispinus*. Nat. size. (From *Danmark's Fauna*.)

Upper marginal plates with a single prominent spine in the middle, lower marginals with a larger spine near the upper edge and a series of spines decreasing in size downwards. Marginal plates otherwise covered with fine spines, the proximal lower marginals being sometimes more or less naked in the middle. Furrow spines 5-6, in larger specimens up to 10-12, the middle one generally slightly the longest. 2-3 larger spines on the adambulacral plates, outside the furrow spines. Arms varying much in length, $R = \text{ca. } 3.5-7 r$. They taper to a fine point. Papularium small, of an elongate, lens-like form. Colour in life a magnificent red or pink or orange ; the oral side whitish. Grows to a size of ca. 13 cm. R.

Development unknown, but the large, yolky eggs indicate that it has probably direct development, without a pelagic larval stage. It appears to reach full size in the course of four years. It prefers a muddy bottom. It would appear that ciliary currents play an important rôle in its feeding, and that its food consists of minute organisms and detritus.

In British seas this species is common in depths of ca. 400-800 m. from off S.W. Ireland to the Faroe Channel; along the North Sea coasts it does not occur. Elsewhere it is distributed from Spitzbergen and the Siberian Sea to the Bay of Biscay, and from the Davis Strait to 42° N. on the American side of the Atlantic. Its bathymetrical distribution is ca. 20-1960 m.

This is a very polymorphic species and has given rise to the establishment of various species which cannot be maintained, or, at most, must rank as varieties. The following varieties may be distinguished:

Var. *platynota* Sladen. The alternation of the marginal plates rather indistinct; papularium inconspicuous; paxillæ generally with a conspicuous central spine; pedicellariæ on adambulacral plates well developed. Colour intensely red.

Var. *nitida* Koehler. Arms narrow from the base, not passing so very gradually into the disk. Upper marginal plates not seen on the dorsal side in the interradii: their spines smaller. The central spine of the paxillæ small. The proximal adambulacral spines each with a pedicellaria.

Var. *Marionis* Perrier. No distinct central spine of paxillæ, or a very inconspicuous one. No pedicellariæ. Spines on marginal plates rather small. Colour lighter.

The two former varieties are mainly cold-water forms, the third a warm-water form. But this is not quite without exception, and none of the characters are quite constant.

2. *Benthopecten* Verrill.

(Syn. *Pararchaster* Sladen.)

Disk small, arms long, tapering; dorsal side with single spines or groups, no paxillæ. Marginal plates with prominent spines. A large, odd interradiial marginal plate, the upper one generally bearing a very conspicuous spine. Adambulacral plates with a comb of small, uniform furrow spines, and one or more larger spines on the outer side. Pedicellariæ pectinate.

One species known from the British seas, but one or two more may be expected to occur there also, viz. *Benthopecten*

(*Pararchaster*) *Fischeri* (Perrier), known from off the N.W. coast of Africa (25° 39' N., 18° 26' W., 1056-1435 m., "Talisman"), and S. of Iceland (62° 10' N., 19° 36' W., 2060 m., "Thor"),¹ and *B. (Pararchaster) Folini* Perrier, known from off the Cape Verde Islands (ca. 2320 m.). It may therefore be preferable to give a key to distinguish these species, while otherwise only the species actually known from British seas, *B. armatus* Sladen, is described in more detail.

Key to the species of Benthopecten known from or likely to occur in the British seas.

1. Upper odd interradiar marginal plate with a single (rarely two) very prominent spine 2
 Upper odd interradiar marginal plate with several not very prominent spines; pectinate pedicellariæ between the lower marginal plates *B. Folini*
2. No pedicellariæ between the lower marginal plates
 1. *B. armatus*
 Pectinate pedicellariæ between the lower marginal plates
 B. Fischeri

1. *Benthopecten armatus* (Sladen). (Fig. 41.)

(Syn. *Pararchaster armatus* Sladen; *Pararch. semisquamatus* var. *occidentalis* Sladen.)

Dorsal side with small spines, 1-3 on a plate, not forming paxillæ. Marginal plates each with a single large spine and generally a few small spinelets, but sometimes wholly naked, excepting the large spine. The lower marginals, especially in larger specimens, usually with a second, somewhat smaller, spine below the first, larger one. Adambulacral spines with a comb of 5-7 small cylindrical furrow spines and one large spine, and one or a few small spinelets on the outer side. Pectinate pedicellariæ may occur on the dorsal side and on the oral interradiar areas, but apparently not between the lower marginal plates. R = ca. 6 r. Largest size recorded, 6 cm. R.

Colour in life, biology, development unknown.

In the British seas this species has been found at 51° 22' N.,

¹ The latter may perhaps rather represent a separate species, but is, in any case, nearest related to *B. Fischeri*. The latter has recently (Grieg, 1921) been maintained to be identical with *B. spinosus* Verrill, which is again maintained to be identical with *B. armatus* Sladen. In the opinion of the present author this is unwarranted, the material at present available not having yielded the intermediate forms to prove the identity of the said species.

12° 41' W., 1767 m. ("Helga"), and further at 50° 22' N., 11° 44' W., 1797 m., and 57° 41' N., 11° 18' W., 1853 m. ("Michael Sars"). It has otherwise only been found by the "Challenger" off the coast of Portugal (depth not recorded).

Possibly this species is identical with *Benthopecten spinosus* Verrill from off the N. American coast (ca. 42° N. to the Mexican Gulf), which may again be identical with *Pararchaster simplex* Perrier from the West Indies. The latter name, which is the

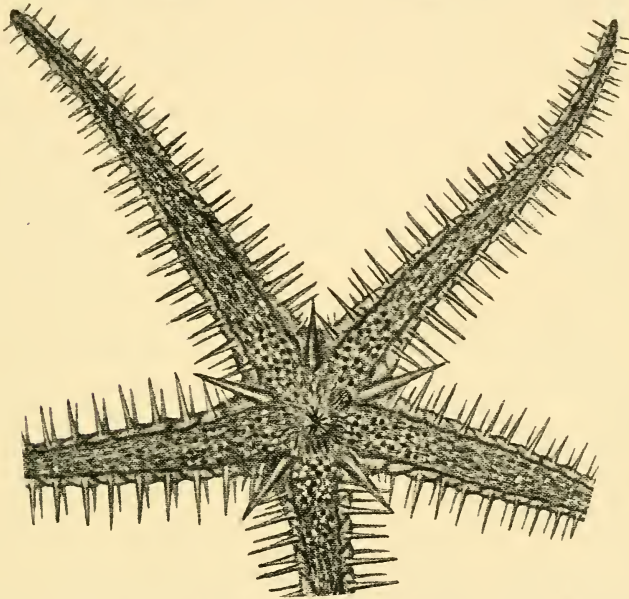


FIG. 41.—*Benthopecten armatus*. Dorsal side. Nat. size. (After Grieg, *Echinod.* "Michael Sars", 1921.)

oldest, should then be adopted. But the identity of the European and American form can hardly be said to be beyond doubt, and it is therefore the safest course, for the present, to use the name *armatus* for the European form, the name *spinosus* for the American form.

3. Suborder. **Valvata** Perrier.

Dorsal side with paxillæ, spines or naked. Marginal plates mostly very conspicuous, covered with grains or spines, not alternating. Pedicellariæ, when present, mostly valvate, more rarely simple. One or two large, recurved, hyaline spines may occur on the jaws. Tube-feet with a sucking disk. No paired dorsal arm muscles.

Three families represented in the British seas. Another family, *Ophidiasteridæ*, is represented in the Mediterranean, along the Moroccan coast and at the Azores, by the two genera *Ophidiaster* and *Hacelia*, each with one species, *O. ophidianus* Lamarck and *H. attenuata* Gray. Both are, however, shallow-water forms, and there is hardly any probability of their occurring in the British seas. They are therefore not included in the key.

The suborder *Valvata* is perhaps not a very natural one. The *Poraniidæ* form a transition to the *Spinulosa*, and also the *Ophidiasteridæ* are rather distant from the *Goniasteridæ*.

*Key to the families of the suborder Valvata known from
the British seas.*

1. A large recurved hyaline spine (or a pair of such spines) usually occurs on the jaws (lacking in the genus *Hoplaster*). Arms short, body rather pentagonal. Marginal plates well developed, covered with spines; an odd interradial marginal plate present I. Fam. *Gnathasteridæ*
- No recurved hyaline spine on jaws; marginal plates naked or with grains or spines, but these latter are never long, slender, and movable; no odd interradial marginal plate 2
2. Marginal plates large and distinct, not covered by a thick skin; edge of disk vertical, not sharp. Dorsal side covered with flat spines (or grains), arranged in the form of paxillæ, or with scattered large spines surrounded by grains

II. Fam. *Goniasteridæ*

Marginal plates smaller, more or less indistinct, carrying spines or covered with naked skin. Edge of disk sharp. Dorsal side covered with a thick, naked skin, or with fine, or even microscopical, spines III. Fam. *Poraniidæ*

I. Family GNATHASTERIDÆ

(Syn. *Odontasteridæ*.)

Marginal plates usually large and distinct; an odd plate in the middle of the interradial. Dorsal side flattened, with mostly short spines or granules, arranged more or less distinctly like paxillæ. Usually one or two (rarely three) large, recurved spines, ending in a hyaline point, on the jaws. Papulæ mainly in the radial. Simple pedicellariæ may be present. Genital organs (so far as known) only at base of arms.

This family is especially richly represented in Antarctic seas, while in the Atlantic only two genera are known to occur, one of these, *Odontaster* Verrill, being represented in the British seas;

the other, *Hoplaster* Perrier,¹ with the single species *H. spinosus* Perrier, is known from the Bay of Biscay (49° 48' N., 15° 02' W., 2995-3307 m. ("Talisman")), and may therefore with great probability be expected to occur also nearer the British coasts.²

Very probably *Pentagonaster lepidus* Sladen, from off the Azores, 1800 m. ("Challenger"), also belongs to the Gnathasteridæ. It bears a great resemblance to *Odontaster mediterraneus*, but is stated to lack the recurved hyaline spine on the jaws. It is only a young specimen (R=7.5 mm.), probably a *Hoplaster*, perhaps only the young *H. spinosus* ("Challenger" *Asteroidea*, p. 275, Pl. LVII. 1-4).

Key to the genera of Gnathasteridæ known from or likely to occur in the British seas.

A single large, hyaline, recurved spine on jaws ; covered with short, slender spinelets	1. <i>Odontaster</i> Verrill
No large recurved, hyaline spine on jaws ; covered all over with long, slender, movable spines	<i>Hoplaster</i> Perrier

1. *Odontaster* Verrill.

Marginal plates large, forming a broad border around the disk, which is pentagonal or broadly stellate. Dorsal side with small, slender spinelets, arranged more or less distinctly in the shape of paxillæ. One large recurved hyaline spine on jaws. Simple pedicellariæ may occur.

One species known from the British (and N.E. Atlantic) seas.

1. *Odontaster mediterraneus* Marenzeller. (Figs. 42-43.)

Body flat, arms short. The whole body covered with a dense coat of slender spinelets, those of the oral side slightly longer. Marginal plates diminishing gradually in size towards end of arms. Furrow spines 3-4 ; on the outer side the adambulacral

¹ The position of the genus *Hoplaster* within the family Gnathasteridæ is not beyond doubt, because of its lacking the large, recurved spine on the jaws, otherwise so characteristic of the family. The general appearance and the presence of a large, odd interradiial marginal plate, however, would seem to indicate its near relationship to *Odontaster*.

² Perhaps this locality might with equal right be reckoned in the British area and the species therefore included in the British Fauna. Since, however, the matter is questionable, and as the author has never seen a specimen of this form, and therefore could only quote the description given by Perrier (*Échinodermes du "Travailleur" et du "Talisman"*, p. 324, Pl. XIV. 2), it has been thought sufficient to give in the key the main characters by which this sea-star can at once be recognised, and otherwise only refer to Perrier's description.

plates carry several similar spines arranged in 2-4 transverse series of 3-4 spines each. Pedicellariæ may occur on the paxillæ



FIG. 42.—*Odontaster mediterraneus*; young specimen. Dorsal side. Slightly enlarged.

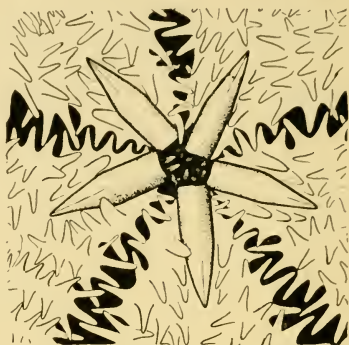


FIG. 43.—Mouth and adjoining parts of oral side of *Odontaster mediterraneus*, showing the five large recurved spines on jaws; from the specimen shown in Fig. 42. $\times 15$.

of the dorsal side. $R = \text{ca. } 2r$. Colour in life unknown. Reaches a size of at least 39 mm. R.

Biology and development unknown.

In British seas this species has been taken at $51^{\circ} 26' \text{ N.}$, $11^{\circ} 45' \text{ W.}$, 990 m. ("Helga").¹ It is elsewhere known only from the Bay of Biscay (1804 m., "Princesse Alice") and from the Mediterranean, 414-1196 m.

II. Family GONIASTERIDÆ

Marginal plates large and distinct. No odd interradial marginal plate. Dorsal side flattened, with short, flat spines, arranged like paxillæ, or with spines surrounded by grains. Pedicellariæ alveolate or valvate, in some forms very large. Papulæ as a rule only in the radial areas. No recurved hyaline spine on jaws. Genital organs in the interradia, not passing into the rays.

This family includes a great number of genera, distributed into several subfamilies (sometimes regarded as separate families), distinguished mainly through differences in the structure of the dorsal skeleton; three of these subfamilies, *Goniasterinæ*, *Pseudarchasterinæ* and *Hippasteriinæ*, are represented in the

¹ Hitherto unpublished record. Two small specimens were taken at this locality.

British seas ; but it seems unnecessary to enter here on the characters of these subfamilies.

The Goniasteridæ is one of the most difficult groups of the Asteroids, especially because of the very intricate synonymy, due to the insufficient definition of the older genera ; the various species may be found under almost any of the older generic names in literature. Too great splitting up of the species has also added to the confusion.

Five genera are represented in the British seas, but three more may be expected to occur there also and are therefore included in the key to the genera. These are : *Peltaster* Verrill (one species, *Peltaster nidarosiensis* (Storm) (syn. *Goniaster nidarosiensis* Storm, *Goniaster acutus* Lütken, *Peltaster hebes* Verrill), known from the Norwegian coast, S. of Iceland, and from the West Indies ; 470-ca. 950 m. ; a very large pentagonal form, reaching a size of 25 cm. diameter) ; *Paragonaster* Sladen (*Paragonaster subtilis* Perrier, known from the Bay of Biscay, 4700 m., and the Azores, ca. 3000 m). To this species are referred as synonyms : *Paragonaster strictus* Perrier, *P. elongatus* Perrier, *P. cylindratus* Sladen, and *P. formosus* Sladen, which gives a distribution from the Bay of Biscay to 1° 47' N. on the European side of the Atlantic and from 41° 7' N. to 24° 33' N. on the American side, and a bathymetrical range of 2455-4700 m. ; *Sphæriodiscus* Fisher (*Sph. (Stephanaster) Bourgeti* Perrier, known from the Azores and off the Cape Verde Islands, 410-760 m.).

Key to the genera of Goniasteridæ known from or likely to occur in the British seas.

1. Marginal plates with a strong spine 5. *Hippasteria* Gray
- Marginal plates with only fine grains 2
2. Upper marginal plates join in the mid-line throughout nearly the whole length of the arms, which are long and slender
3. *Nymphaster* Sladen
- At most the 2-3 outer upper marginals contiguous 3
3. Arms of medium length, R = ca. 3 r 4
- Arms short, body rather pentagonal, R = ca. 1.3-2 r 5
4. Arms very narrow. Upper marginal plates separated by a single series of dorsal plates, which have not the shape of paxillæ ; no pedicellariæ *Paragonaster* Sladen
- Arms rather broad. Upper marginal plates separated by several series of dorsal plates ; pectinate or valvate pedicellariæ
4. *Pseudarchaster* Sladen
5. Second or third marginal plate from the point, in both series, enlarged *Sphæriodiscus* Fisher
- Marginal plates evenly decreasing towards the end of arm 6

6. Covering of dorsal side arranged in the form of paxillæ

1. *Ceramaster* Verrill

Covering of dorsal side not in the form of paxillæ . . . 7

7. Dorsal plates closely granulated ; large bivalve pedicellariæ, both on upper and under side *Peltaster* Verrill

Dorsal plates naked centrally, surrounded by a single series of granules on the radial areas ; pedicellariæ small

2. *Plinthaster* Verrill

Subfamily GONIASTERINÆ

1. *Ceramaster* Verrill.

Body mostly pentagonal ; arms short, sometimes so short as to represent merely the corners of the body. 1-3 of the distal upper marginals joining in the dorsal mid-line. Dorsal plates entirely covered with granules, arranged in sharply limited groups, resembling paxillæ. Marginal plates covered with granules, but often with a naked part in the middle. Oral inter-radial plates covered with granules. Pedicellariæ small, bivalved, or with two or three spatulate jaws, usually not in deep pits.

Three species are recorded from the British seas, but one more is likely to occur there also, viz. *Ceramaster placenta* (Müll. and Troschel) ; (syn. *Goniodiscus placenta* Müll. and Troschel ; *G. placentaeformis* Heller ; *G. acutus* Heller ; *Pentagonaster mirabilis* Perrier ; (?) *P. crassus* Perrier ; *Pentagonaster minor* Koehler), known from the Bay of Biscay (ca. 200-400 m.), and from the Mediterranean (10-160 m.). Also *Ceramaster* (*Pentagonaster*) *Vincenti* Perrier, from off Morocco, 946-1105 m. ("Talisman") may possibly occur in the British seas. These species, therefore, are included in the key.

One of the species recorded from the British seas (S.W. of Ireland, 1800 m., "Flying Fox"), *Ceramaster Greeni* (Bell) is too insufficiently known to be placed in the key, and, for the present, reference can only be given to the description and figure given in Bell's *Catalogue*, p. 74.¹

¹ Dr. C. C. A. Monro has kindly given me the following additional information about the type-specimen which is in the British Museum. The marginal plates are—or were once—covered with a fine granulation, but whether they were wholly or only partly covered is impossible to say, because all the grains have been rubbed off, except in a few patches. The marginal plates appear to be all alike, and Bell's figure gives a good idea of their general outline. The madreporite can only be distinguished with difficulty, Bell's figure being wholly misleading in this particular. The paxillæ of the dorsal side are round, with ca. 12-16 peripheral and ca. 7-15 central granule-like spinelets.

Key to the species of Ceramaster known from or likely to occur in the British seas.

1. Marginal plates wholly covered with granules, at most some of the outer upper marginals with a naked part 2
Both upper and lower marginals with a naked part 1. *C. granularis* (O. F. Müll.)
2. Pedicellariæ wholly wanting *C. placenta* (Müll. and Trosch.)
Pedicellariæ present 3
3. A conspicuous series of pedicellariæ along each side of the ambulacral furrows *C. Vincenti* (Perrier)
No conspicuous series of pedicellariæ along the ambulacral furrow but some scattered ones on the dorsal plates 2. *C. balteatus* (Sladen)
Insufficiently known species *C. Greeni* (Bell)

1. *Ceramaster granularis* (O. F. Müller). (Fig. 44.)

(Syn. *Goniaster*, *Pentagonaster*, *Tosia granularis*; *Astrogonium granulare* (O. F. Müll.); *Astrogonium boreale* Barrett; *Pentagonaster Deplasi* Perrier.)

Body pentagonal, arms very short. Marginal plates, both upper and lower, with a naked area near the edge, larger in the younger than in the adult specimens. Adambulacral plates with 4 or 3 furrow spines and outside these some short club-shaped

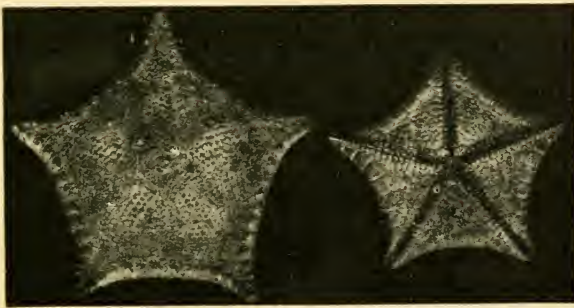


FIG. 44.—*Ceramaster granularis*, from the dorsal and the oral side. Nat. size. (From *Danmark's Fauna*.)

spines, two nearer the furrow spines, and some other, less regularly arranged, outer ones, forming the transition to the grains of the interradial plates. Pedicellariæ may occur on the dorsal paxillæ (Fig. 26, 3), but are often wanting. $R = 1.3-1.4 r$. Colour bright red, lighter on the oral side. Reaches a size of ca. 80 mm. diameter.

Development unknown, but the large, yolky eggs indicate that

it probably has direct development, without a pelagic larval stage. Nothing is known about its food. It may be found on all sorts of bottom.

In the British seas this species has been recorded from the Faroe Channel, 440 fms. ("Porcupine"), from the Lousy Bank, and from 50 miles W.N.W. of Eagle Island, N. Mayo, 388 fms. ("Helga"). Elsewhere it has a very wide distribution; on the Scandinavian coasts it occurs from Finmark to Skagerrack; it is further recorded from off Morocco and the Azores, and from Greenland down to 41° N. on the American coast. The bathymetrical distribution is ca. 20-1400 m.

2. *Ceramaster balteatus* (Sladen). (Fig. 45.)

(Syn. *Pentagonaster Gosselini* Perrier; (?) *P. hystricis* v. Marenz.; (?) *P. Kergroheni* Koehler; (?) *P. hesitans* Perrier.)

Body less distinctly pentagonal, arms more distinct and interradia forming a more pronounced arch than in the preceding species. Marginal plates wholly covered with granules. Adamblacral plates with 5-4 furrow spines, and outside these a series

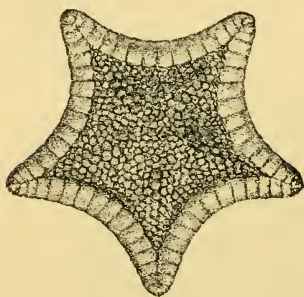


FIG. 45. — *Ceramaster balteatus*, dorsal side. Nat. size. (After Sladen, *Echinod. S.W. Ireland.*)

of mostly three club-shaped spines and some outer spines which are quite similar to those of the interradial plates. Small pedicellariæ may occur, mainly on the marginal plates. $R = \text{ca. } 1.8 r$. Not known to grow to a larger size than 44 mm. diameter. Colour in life light yellowish-red.

Development and biology unknown.

In British seas this species has been found only off S.W. Ireland in 750-795 fms. (Green, "Helga").

It is further known from the Azores and the Cape Verde Islands, 946-1770 m.

It seems not improbable that this species is identical with the Mediterranean species *Ceramaster* (*Pentagonaster*) *hystricis* (v. Marenzeller), with which again the species *Kergroheni* Koehler from the Bay of Biscay appears to be identical, the character especially distinguishing the latter: a naked space on the distal upper marginals, also being found in larger specimens of the Mediterranean *C. hystrix*. It is not yet known whether such

naked spaces may occur also on the distal marginals of *balteatus*, and it is therefore not safe definitely to declare *C. hystrix* and *Kergroheni* to be synonyms of *balteatus*. The *Pentagonaster hæsitans* Perrier (off Morocco, 2210 m.) also seems very nearly related to, perhaps identical with, *C. balteatus*; it bears also much resemblance to Bell's *Pentagonaster Greeni*.

2. *Plinthaster* Verrill.

(Syn. *Pyrenaster* Verrill.)

Body pentagonal, but the point of the rays may be well marked off from the disk. Dorsal plates naked, with only a circle of grains round the edge. Marginal plates with granules, but naked to a variable extent. Oral intermediate plates covered with granules. Pedicellariæ in deep pits on the dorsal and oral interradial plates, sometimes also on the marginal plates.

Only one species known from the British seas (and the North-east Atlantic).

1. *Plinthaster Perrieri* (Sladen). (Fig. 46.)

(Syn. *Pentagonaster Perrieri* Sladen; *concinus* Sladen; *grandis* Perrier; (?) *dentatus* Perrier.)

Rays well marked off from disk; the last five upper marginals join in the dorsal mid-line. Marginals partly naked, the grains

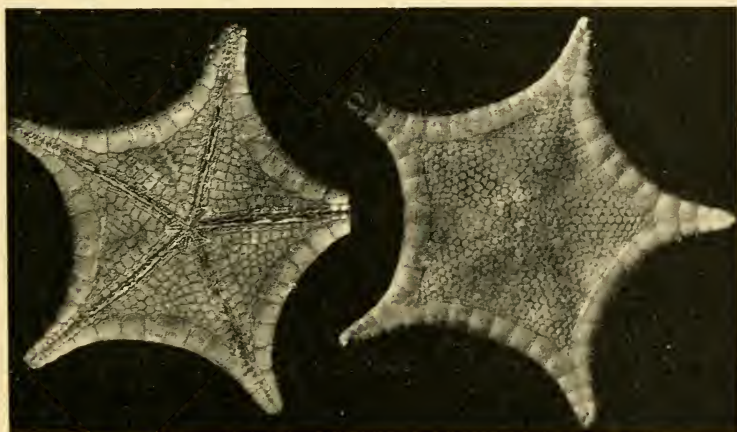


FIG. 46.—*Plinthaster Perrieri*; oral and dorsal side. Nat. size.

more or less scarce in their median part. The grains easily fall off, leaving rather deep impressions in the plate. Adambulacral

plates carry a series of 6-7 (5-8) short, blunt furrow spines, and outside these two fairly regular longitudinal series of 4-5 small, more grain-like spines. Dorsal plates with fine, glassy warts inside the circle of grains (Fig. 47). $R = \text{ca. } 1.8 r$. Grows to a considerable size, 95 mm. $R.$, 63 $r.$ being the largest specimen recorded. Colour in life yellowish-red.

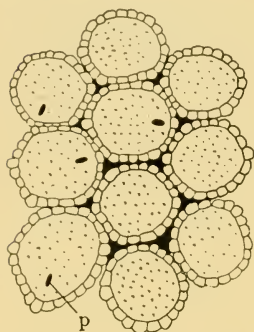


FIG. 47.—Dorsal plates of *Plinthaster Perrieri*. $\times 9$.

p, Groove of pedicellaria.

Biology and development unknown.

It has been taken several times ("Helga", "Michael Sars", etc.) off the west coast of Ireland, in depths of ca. 600-1450 m., but only a few specimens at a time. Further known from the Bay of Biscay, off the coasts of Spain and Morocco, as far south as the Cape Verde Islands, and at the Azores. Bathymetrical distribution ca. 600-1800 m.

Some authors regard this species as identical with the West Indian *Pl. dentatus* (Perrier). The present author does not feel convinced of their identity, and therefore thinks it safest, at least for the present, to keep the name *Pl. Perrieri* for the East Atlantic form.

3. *Nymphaster* Sladen.

Body pentagonal, with long, slender rays. Dorsal marginal plates join in the mid-line of the rays for nearly their whole length; the dorsal plates confined to the disk, polygonal. Both dorsal, marginal, and oral interradial plates covered with grains. Small pedicellariæ may occur on dorsal, marginal, and oral interradial plates.

One species known to occur in the British seas.

1. *Nymphaster arenatus* (Perrier). (Fig. 48.)

(Syn. *Pentagonaster arenatus* Perrier; *Dorigona arenata* (Perrier); *D. Jacqueti* Perrier; *D. prehensilis* Perrier; *Nymphaster protentus* Sladen. (?) *Pentagonaster* (*Dorigona*, *Nymphaster*) *subspinosus* Perrier.)

Marginal, dorsal, and oral interradial plates covered by a uniform granulation, the grains being not placed so close as to touch one another, and therefore round, not angular. Adambu-

lacrual plates with 6-8 (9) rather slender furrow spines, and outside these some grains arranged more or less distinctly in two longitudinal series. The furrow spines are arranged comb-like along the edge of a rounded projection of the adambulacral plate, which joins that of the opposite plate, thus bridging over the ambulacral furrow, each two successive plates having a round space between them. Thus the ambulacral furrow, especially in the outer part of the arm, assumes the shape of a series of fairly large, round, well-separated pores. $R = \text{ca. } 4.5\ r$. Grows to a size of ca. 110 mm. R. Colour in life yellowish-red.

Biology and development unknown.

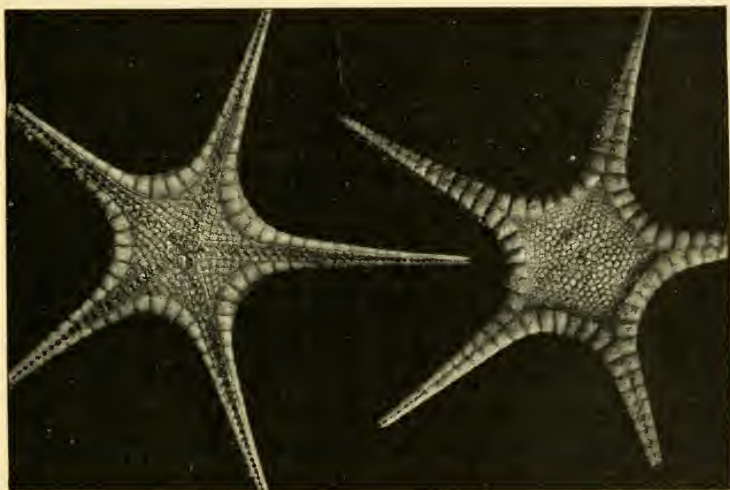


FIG. 48.—*Nymphaster arenatus* ; oral and dorsal side. Nat. size.

In British seas this species is known from off west Ireland from depths of ca. 400-1300 m. ("Flying Fox", "Helga"); it appears to be fairly common in places. It is further known from the Bay of Biscay to the Canaries. Also known from the West Indies. Bathymetrical distribution ca. 400-2790 m.

It may be doubted whether it is really identical with *Nymphaster subspinosus* (Perrier), which is distinguished by having some spines on the marginal plates in the interradii. A specimen of this form has been found in the Bay of Biscay; it may therefore be expected to occur also in the British seas.

Subfamily PSEUDARCHASTERINÆ

4. *Pseudarchaster* Sladen.

Arms rather long, mostly ca. 3 times the disk radius. Dorsal side covered with paxillæ; they continue to the end of the arms, none of the upper marginal plates joining in the dorsal mid-line. Marginal plates wholly covered with grains, the lower marginals mostly also with some larger, appressed spines. Oral interradiar area fairly large, covered with grains and spines, more rarely with grains alone. The grains along the sutures of the plates, especially those adjoining the adambulacral plates, often regularly arranged so as to form with those of the adjoining plate a sort of pedicellariæ (pectinate pedicellariæ, see Fig. 26, 2); small bivalve pedicellariæ may also occur.

Only one species, *Ps. Parelii*, known from the British seas, but very probably more species will be found to occur there. No less than nine other species have been recorded from the area Bay of Biscay, Azores, Cape Verde Islands, viz. *Pseudarchaster (Astrogonium) fallax* (Perrier) (known from off the Azores and off the N. American coast, ca. 1100-2200 m.); *Ps. (Astrog.) necator* (Perrier) (Azores, ca. 1250-1900 m.); *Ps. (Astrog.) annectens* (Perrier) (Bay of Biscay, Azores, ca. 900-1900 m.); *Ps. (Astrog.) hystrix* (Perrier) (off Morocco, 840 m.); *Ps. (Astrog.) aphrodite* (Perrier) (off Morocco, 1090 m.); *Ps. (Astrog.) æquabile* (Koehler) (Azores, 1900 m.); *Ps. (Astrog.) eminens* (Koehler) (Azores, 1095-1940 m.); *Ps. (Astrog.) marginatus* (Koehler) (off the Azores, 1805 m.); *Ps. (Aphroditaster) gracilis* (Sladen) (off the Azores, 1800 m.). The author not having had an opportunity of studying all these species on authentic specimens, and the descriptions and figures found in the literature being more or less unsatisfactory, a key cannot be given, and reference can only be made to the three works containing the descriptions, viz. Perrier's *Échinodermes du "Travailleur" et du "Talisman"* (1894), Koehler's *Échinodermes, Res. Camp. Scientif.*, Monaco, fasc. xxxiv. (1909), and Sladen's "*Challenger*" *Asteroidea*. But it may well be suggested that most of these nine "species" will ultimately prove to be untenable and to be synonyms only of some other species.

1. *Pseudarchaster Parelîi* (Düben and Koren). (Fig. 49.)

(Syn. *Astropecten*, *Archaster*, *Plutonaster*, *Tethyaster*,
Astrogonium Parelîi (Düb. and Kor).)

Upper marginal plates covered with close-set, flat-topped, hexagonal granules, those along the sutures somewhat smaller. Lower marginals with some appressed spines along the mid-line. Oral interradiæ plates with small spines and a few larger ones among them. Adambulacral plates with 5-6 furrow spines, and outside these one or two somewhat enlarged spines surrounded by some smaller ones not arranged in regular series. Generally 3-6 pectinate pedicellariæ along the adambulacrals; no bivalve

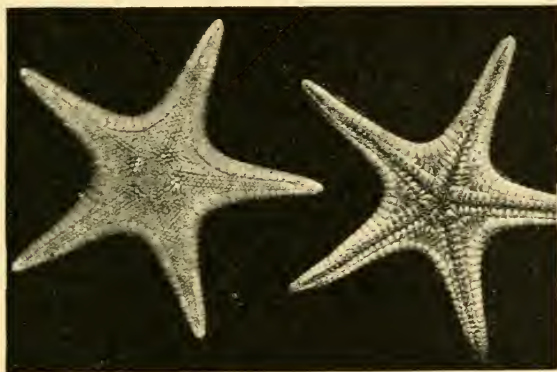


FIG. 49.—*Pseudarchaster Parelîi*, dorsal and oral side. Nat. size (small specimen). (From *Danmark's Fauna*.)

pedicellariæ. $R = \text{ca. } 3 r$. Colour in life red-brown or red on the upper side, lighter coloured on the oral side.

Grows to a very considerable size, to nearly 20 cm. R. It would seem to take at least four years in reaching adult size. It appears to feed, partly at least, on detritus, which is carried to the mouth by ciliary currents. Development unknown.

Var. *longobrachialis* Dan. and Koren is distinguished by relatively somewhat longer and more slender rays, but especially by the dorsal marginal plates being narrower, encroaching less on the dorsal surface than in the type; in accordance herewith there is more room for the paxillæ, which are somewhat larger in the variety than in the typical form.

In British seas this species has been taken off N. and W. Ireland ("Porcupine", "Helga"), in ca. 500-1100 m., but only in small

numbers ; also recorded from the Rockall Bank. It is not known to the south of the British area ; to the north it is distributed along the Scandinavian coasts as far north as the Murman coast ; also known from S. Greenland to ca. 38° N. along the American coast. Further, it occurs in the Northern Pacific. Bathymetrical distribution, 15-ca. 2500 m.

The variety is known hitherto only from the Scandinavian seas and from west Greenland.

Subfamily HIPPASTERIINÆ

5. *Hippasteria* Gray.

(Syn. *Hippasterias*.)

Disk large, arms short. Dorsal side with thick spines, surrounded by a circle of smaller grains. Marginal plates with a thick, prominent spine. Numerous large bivalve pedicellariæ.

Only one species in British (and European) seas. (Several other species in the North Pacific.)

1. *Hippasteria phrygiana* (Parelius). (Fig. 50.)

(Syn. *Goniaster*, *Astrogonium phrygianum* ; *Goniaster equestris* (Forbes) ; *Hippasteria plana* (Link) ; *Hippasteria europæa* Gray ; *H. Johnstoni* Gray.)

Plates of dorsal side of various sizes ; larger ones with a thick spine or a pedicellaria in the middle and a series of grains around the edge, and smaller ones irregularly disposed among the former, carrying grains or pedicellariæ. Marginal plates each with 1-3 thick spines in the middle and a series of grains along the edges. Oral interradial area very large, with numerous large pedicellariæ, each surrounded by a circle of grains (Fig. 26, 4). Along the ambulacral furrow the pedicellariæ are arranged in a fairly regular longitudinal series, each pedicellaria standing obliquely to the furrow. 2-3 robust furrow spines ; on the outer surface of adambulacrals generally only one large spine. R=ca. 2 r. Colour in life beautifully red. Grows to a very considerable size, ca. 200 mm. R.

It feeds on echinoderms, mussels, worms ; apparently also on detritus. Development unknown, but its large, yolky eggs indicate that it has probably direct development, without a pelagic larval stage.

In British seas it has been recorded from Plymouth Sound,

Cornwall, the west and east coast of Scotland, down to Northumberland; also from Rockall Bank. Apparently it is rather rare. Along the Scandinavian coasts it is distributed from the Kattegat

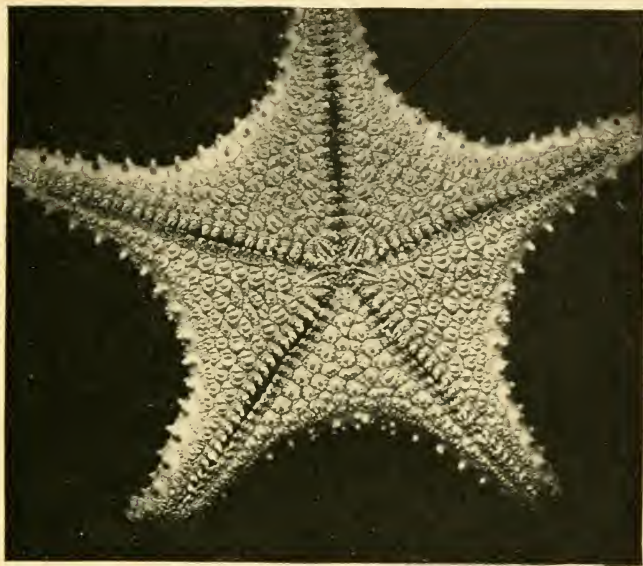


FIG. 50.—*Hippasteria phrygiana*. Oral side. Slightly reduced.
(From *Danmark's Fauna*.)

to Finmark. It is further known from Iceland and from Greenland to 42° N. on the American coast. Also recorded from S. Africa, but very probably this South African form is not really *H. phrygiana*. Bathymetrical distribution ca. 20-800 m.

II. Family PORANIIDÆ¹

Marginal plates less distinct, partly overlapping. Dorsal side convex, covered by a thick skin, naked or with short, conical, isolated spines, or with a close covering of fine, microscopical spines. No pedicellariæ. Papulæ scattered over the dorsal side. Genital organs in the interradii, not passing into the ray.

Three genera represented in British seas. A fourth, *Tylaster* Dan. and Koren, with only known species *T. Willei* Dan. and Koren, hitherto known only from the deep sea between Iceland,

¹ This family is named *Asteropidæ* in Koehler's *Échinodermes des mers d'Europe* and *Faune de France*, i.; in Bell's *Catalogue of British Echinoderms* it is named *Gymnasteridæ*.

Greenland, and Spitzbergen, 520-2700 m., may well be expected to occur also in the cold area of the Faroe Channel, and is therefore included in the key.

Key to the genera of Poraniidae known from or likely to occur in the British seas.

1. Dorsal side entirely devoid of a skeleton but set with fine spines.
Oral interradiial areas with small plates in isolated transverse series, and with spines in transverse series, parallel to the spines of the lower marginals *Tylaster* Dan. and Koren
Dorsal side with skeletal plates, oral interradiial plates not arranged in isolated transverse series 2
2. Dorsal side with isolated, conical spines 3. *Marginaster* Perrier
Dorsal side naked, or with a close coat of microscopical spines, or with grains 3
3. Dorsal side naked; spines on the lower marginal plates rather coarse, forming a distinct fringe along the edge of the disk
1. *Porania* Gray
Dorsal side with grains or with a close covering of microscopical spines.¹ The spines of lower marginal plates fine, only indistinctly forming a fringe along the edge of the disk, or are wholly wanting 2. *Poraniomorpha* Dan. and Koren

1. *Porania* Gray

Disk large, convex; rays short, but distinct. Dorsal side covered with a thick, naked skin, entirely without spines. Lower marginals with 3-5 fairly strong spines, forming a fairly distinct fringe along the edge of the body.

Only one species in British (and European) seas.

1. *Porania pulvillus* (O. Fr. Müller). (Fig. 51.)

(Syn. *Asteropsis pulvillus* (O. Fr. Müller); *Goniaster Templetoni* Forbes.)

Dorsal surface smooth and greasy to the touch, the only processes on it being the scattered groups of papulae. When dried the dorsal skeleton can be discerned through the skin. Upper marginal plates naked, narrow, leaving between their lower ends a space in which papulae may occur. Oral inter-radial area naked, often with distinct radiating furrows. Ambul-

¹ As these fine spines are enclosed in thick skin, it is not easily seen directly whether the skin is really or only apparently naked, and it may be necessary to examine a small piece of the skin microscopically in order to ascertain whether spines are present or not. In dried specimens the spines are easily discerned with a lens.

acral grooves narrow ; adambulacral plates carrying one furrow spine and another on the outer surface, these two forming a

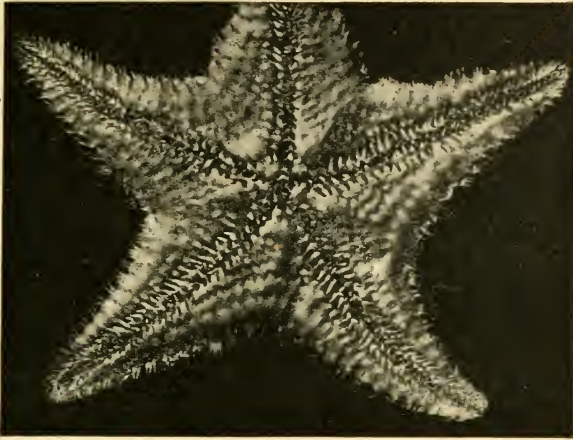


FIG. 51.—*Porania pulvillus*, oral side. Slightly reduced. (From *Danmark's Fauna*.) (An excellent figure of the dorsal side of this species is given in Bell's *Catalogue Brit. Echinod.*, Pl. X.)

regular double series of spines along each side of the ambulacral grooves. $R = \text{ca. } 1.5-2 r$. Grows to a size of ca. 110 mm. diameter. Colour in life bright red or yellowish-white, spotted or mottled ; the under side white. Altogether a very beautiful sea-star.

Regarding its food it has been proved that detritus, drawn into the stomach by ciliary currents, plays an important rôle ; larger animals have not been found in its stomach, and it appears that it will not eat in aquaria.

The larva (Fig. 52) is a Bipinnaria with a Brachiolaria stage, peculiar through its short arms and through having a series of papillæ along the edge of the Brachiolaria arms.

In British seas this species occurs along the southern, western, and northern coasts, down to the

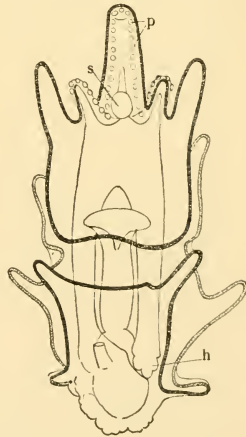


FIG. 52.—Larva, in the Brachiolaria stage, of *Porania pulvillus*. Ca. $\times 25$. (After Gemmill ; from *Danmark's Fauna*.)

h, Hydrocoel, or watervascular system ; p, Papillæ ; s, Sucking disk.

Moray Firth, but apparently not farther south along the North Sea coasts; it is also recorded from the Lousy Bank. Elsewhere distributed from Trondhjemfjord on the Scandinavian coasts to the Bay of Biscay; not known from the American coast. It has been found at depths of ca. 10-1000 m., but appears to be more common in shallower depths, down to ca. 200-300 m.

2. *Poraniomorpha* Danielssen and Koren.

(Syn. *Rhegaster* Sladen; *Lasiaster* Sladen; *Culcitopsis* Verrill.)

Disk large, convex, rays short, but generally distinct. Dorsal side covered with a close coat of fine microscopical spines or with small grains. Spines on lower marginals fine, not forming a distinct fringe along edge of disk.

Only one species is known from the British seas, but another species, *P. tumida* (Stuxberg), will be found very likely in the cold area of the Faroe Channel. This is an Arctic species, distinguished from *P. hispida* by the disk being covered with fine, rounded grains, and the lower marginals and oral interradiial plates being without spines. Papulae in groups of generally less than 10.

1. *Poraniomorpha hispida* (M. Sars). (Fig. 53.)

(Syn. *Goniaster hispidus* M. Sars; *Lasiaster villosus* Sladen; *Rhegaster Murrayi* Sladen; *Poraniomorpha rosea* Dan. and Koren; *Culcita borealis* Süssbach und Breckner; *Culcitopsis borealis* (Süssbach und Breckner).)

Dorsal side covered by a close coat of fine spines. Papulae in groups of ca. 20 or more. Marginals forming a rather distinct, more or less vertical edge. Lower marginals with a group of short spines forming a faint fringe around the disk. Oral interradiial areas with scattered, fine spines. Adambulacral plates with 2 furrow spines and 3-4 spines in a transverse series on the outer side. $R = \text{ca. } 1.5-2r$. Grows to size of ca. 80 mm. diameter. Colour in life yellow or reddish-brown; often only the arm points reddish.

The length of the arms rather varying; in the more long-rayed forms, the var. *rosea* Dan. and Koren, $R = 2r$; but in others the rays are so short that the body becomes almost pentagonal. Specimens with wart-like elevations on the dorsal side have been distinguished as var. *tuberculata*. The disk may be very much swollen; such specimens have a superficial resemblance to the tropical genus *Culcita*, and have, indeed, been described as a northern species of this genus, *Culcita borealis*

Süssbach und Breckner, which has even been raised to the rank of a separate genus, *Culcitopsis* Verrill. But there is hardly any doubt that this is simply a synonym of *Poraniomorpha*.

It appears to feed, partly at least, on detritus, which is carried to the mouth by ciliary currents. Development unknown.

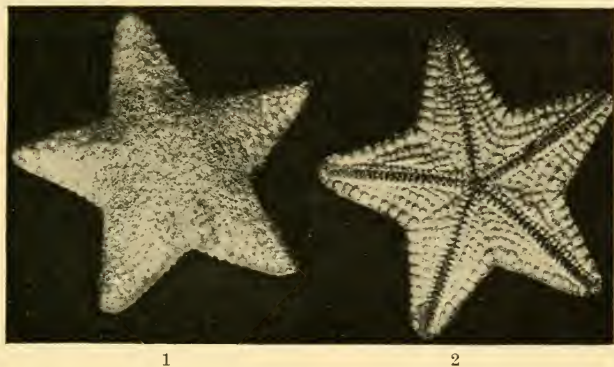


FIG. 53.—*Poraniomorpha hispida*. 1. Dorsal. 2. Oral side.
Nat. size. (From *Danmark's Fauna*.)

In British seas this species is known from the Faroe Channel, the Lousy Bank, and off S.W. Ireland ("Porcupine", "Triton", "Helga"). It is further distributed from the Skagerrak to Northern Norway, and from S. Greenland to 35° N. along the American coast. Bathymetrical distribution ca. 90-1170 m.

3. *Marginaster* Perrier.

(Syn. *Cheilaster* Sladen.)

Disk small, flattened; rays very short, body pentagonal. Dorsal side with scattered, short, conical spines. Marginals low, but distinct, with spines forming a fringe.

Only one species known from the British seas, but possibly another may occur there also, viz. *M. pentagonus* Perrier (see below).

1. *Marginaster capreensis* (Gasco). (Fig. 54.)

(Syn. *Cheilaster fimbriatus* Sladen; (?) *Marginaster pentagonus* Perrier.)

Spines of upper marginal plates, when present, shorter than those of lower marginals. Oral interradiar areas with a few small spines or wholly naked; generally with distinct radiating furrows. Adambulacral plates with one furrow spine and two on the outer

surface, forming two longitudinal series along each side of the ambulacral furrow. $R=1.2-1.4\ r$. Appears to reach only a small size; not known to exceed ca. 20 mm. diameter. Colour in life, red or yellowish-red.

Biology and development unknown.

In British seas this species has been found only once, $56^{\circ} 15' N.$, $11^{\circ} 25' W.$, 2487 m. ("Porcupine"). Otherwise known only from the Mediterranean from ca. 50-600 m.

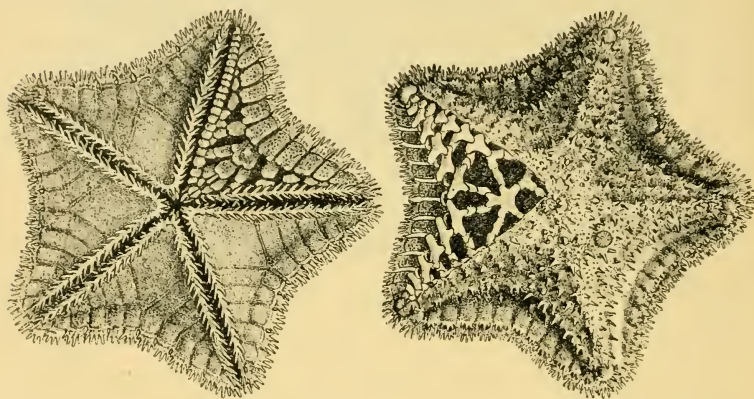


FIG. 54.—*Marginaster capreensis*, oral and dorsal side. One interradius has been denuded so as to show the skeletal plates. Slightly reduced. (From Marenzeller.)

The form described by Perrier under the name of *Marginaster pentagonus* (Bay of Biscay, 400 m.) is distinguished from *M. capreensis* by having numerous small spines on the dorsal plates and (2) 3 outer spines on the adambulacrals. This may perhaps prove to be a distinct species; however, so long as only the single small type-specimen is known ($R=3\text{ mm.}$) it must be left undecided, whether it is a separate species or only a synonym of *M. capreensis*. If a distinct species it may well be expected to occur also in British seas.

II. Order. SPINULOSA Perrier.

Marginal plates generally inconspicuous, not forming a vertical edge to the disk. Dorsal and oral side covered with spines, mostly in groups on prominences from the plates, forming paxillæ, more rarely isolated. Simple pedicellariæ may occur (in the family Asterinidæ). Papulæ mostly both on the dorsal and ventral side. Tube-feet, with a single exception, in two series,

always provided with a sucking disk. The number of the rays five or many.

Six families belonging to this order are represented in British seas, and probably two more, viz. the *Chætasteridæ* and *Myxasteridæ*, will be found to occur there also. Of the former, one species, *Chætaster longipes* (Retzius), has been found in the Bay of Biscay (130 m.) (elsewhere found in the Mediterranean, along the Moroccan coast, and at the Azores, ca. 30-1140 m.);¹ of the latter, one species, *Myxaster Perrieri* Koehler, has been found in the Bay of Biscay, 1300 m.; another, *Myxaster sol* Perrier, between the Canaries and the Cape Verde Islands, 1400-1550 m. (the two species are easily distinguished by the number of arms, *M. Perrieri* having 6, *M. sol* 9-10 arms). These two families are therefore included in the key, but not otherwise treated here.

Key to the families of Spinulosa known from or likely to be represented in the British seas.

1. Body more or less flattened, with a distinct edge forming a sharp limit between dorsal and oral side 2
 No distinct edge, no sharp limit between dorsal and oral side 4
2. A finlike membrane along the edge of the body; paxillæ of the dorsal side covered by a membrane which lies like a roof over the whole dorsal side III. Fam. *Pterasteridæ*
 The edge of the body formed by the more or less distinct marginal plates, not by a finlike membrane. No membrane forming a roof over the dorsal side 3
3. Marginal plates rather indistinct. Dorsal side covered with scalelike, imbricating plates carrying small spines placed in irregular groups or forming very low paxillæ

II. Fam. *Asterinidæ*

Marginal plates distinct, paxillæ-like, in a double series. Dorsal side with small, independent plates carrying slender paxillæ

I. Fam. *Radiasteridæ*

4. Disk very small; arms 5, long, slender, cylindrical; spines small, singly or in very low, paxillæ-like groups 5
 Disk fairly large; arms 5 or more; spines rather long, forming very distinct, conspicuous paxillæ 6
5. Spines single or in small groups which do not show a regular serial arrangement. Spines not glassy

VI. Fam. *Echinasteridæ*

Spines in very dense groups, forming low paxillæ which are arranged in very regular longitudinal series. Spines glassy

Fam. *Chætasteridæ*

¹ The statement of its occurrence at the Bermuda Islands rests on a misidentification; the Bermuda form is *Chætaster nodosus* Perrier, not *Ch. longipes*.

6. A single or double series of larger marginal paxillæ. Oral inter-radial plates present. Spines on adambulacral plates in two series at right angles V. Fam. *Solasteridæ*
 No larger marginal paxillæ. Oral interrarial plates absent or indistinct 7
7. Arms 5,¹ short; spines on adambulacral plates forming together with those of lower marginals a single transverse series, not webbed IV. Fam. *Korethrasteridæ*
 Arms 6 or more, long, slender; adambulacral spines webbed, not associated with those of lower marginals Fam. *Myxasteridæ*

I. Family RADIASTERIDÆ

(Syn. *Mimasteridæ*.)

Dorsal side covered with paxillæ, borne by small, mostly independent plates. Upper and lower marginals small, but distinct, paxilliform, forming a distinct edge to the body, delimiting the dorsal from the ventral side. Oral interrarial plates in transverse series, imbricated, with tufts of spinelets (paxillæ).

This family is sometimes placed among the Phanerozonia, to which it has no doubt a close relation; the author, however, thinks it more naturally placed among the Spinulosa. In any case, it has near relations to both orders, and should perhaps rather be regarded as a connecting link between these two orders.

Only one genus represented in British (and European) seas.

1. *Radiaster* Perrier.

(Syn. *Mimaster* Sladen.)

Plates of the dorsal side, also those at the sides, simple, not imbricating. Tube-feet with well-developed sucking disk. Genital organs confined to the disk. Hepatic cæca with long subdivisions, so that each ray appears to have 6-10 separate cæca of unequal length.

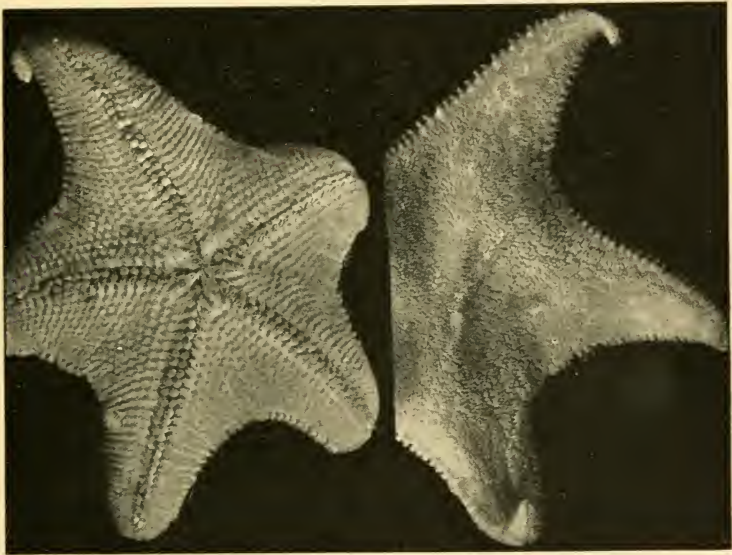
(The only other genus known of this family, *Mimastrella* Fisher, with the species *M. (Mimaster) cognatus* (Sladen) from the S.W. Atlantic, differs from *Radiaster* in the lateral dorsal plates being four-lobed, imbricated, in the tube-feet having only a rudimentary sucking disk, the genital organs extending for over half the length of rays, and in the cæca being simple. There is not much probability that this form will occur in the N.E. Atlantic.)

Only one species known from the British (and European) seas.

¹ Exceptionally there may be 6 arms in *Korethraster*.

1. *Radiaster Tizardi* (Sladen). (Fig. 55.)(Syn. *Mimaster Tizardi* Sladen.)

Dorsal side rather high, sometimes much swollen and with a deep furrow in the interradial mid-line. Rays short, broad, tapering. Paxillæ of dorsal side not arranged in regular series; each composed of ca. 15-20 short, delicate, erect spinelets. Lower marginal plates somewhat larger than the upper. Oral interradial areas very large, extending to the end of the rays.

FIG. 55.—*Radiaster Tizardi*, oral and dorsal side. Slightly reduced.

Adambulacral plates with 2-3 furrow spines and 15-20 slender, erect spines on the outer surface. $R = \text{ca. } 2 r$. Grows to a considerable size, at least 120 mm. R. The arms of preserved specimens are often curved upwards.

Colour in life unknown. Biology and development unknown.

The species is known only from the British seas, from the Faroe Channel ("Triton", "Knight Errant") and off S.W. Ireland ("Helga"), ca. 700-1500 m. Appears to be not very rare in these localities.

II. Family ASTERINIDÆ

Dorsal side covered with imbricating, scale-like plates carrying small spines placed in irregular groups or in paxillæ-like tufts. Body rather pentagonal, flattened, with a sharp edge, formed by the small, mostly rather indistinct marginal plates. Oral interradii large, with regular, imbricated plates carrying a few spinelets or granules.

Two genera in the British (and European) seas.

Key to the genera of Asterinidæ of the British seas.

Body very flat and thin, with a crest-like thickening along each ray. Very large, 10-12 cm. diameter 2. *Palmipes* Linck
 Body slightly swollen, not very thin; no crest along rays. Small, 4-6 cm. diameter 1. *Asterina* Nardo

1. *Asterina* Nardo.

Body subpentagonal; dorsal side slightly swollen, oral side flat. Rays short; no crest along the mid-dorsal line. Spines small, arranged in irregular groups on the dorsal side, fewer and somewhat stronger on the oral interradii. Papulæ in five broad radial areas and on middle of disk. Simple pedicellariæ may occur.

Only one species in British (and European) seas.

1. *Asterina gibbosa* (Pennant). (Fig. 56.)

(Syn. *Asteriscus verruculatus* Müller and Troschel.)

Spines on the dorsal plates in groups of 4-8. Pedicellariæ, formed by two slightly curved, opposing spines, not rarely found between the spine groups. Spines of oral interradii in groups of 2-3, somewhat larger than those of the dorsal side. Adambulacral plates with 4 furrow spines and 2 on the outer surface. Female genital openings on the oral side, large and conspicuous. R = ca. 1.2-2 r. Reaches a size of ca. 6 cm. diameter. Colour in life, olive-greenish, or yellowish or brownish-red.

It is mainly a littoral species, living on and below stones, but may also be found among algæ, *Zostera*, sponges, etc. In deeper water it occurs mainly on shell bottom. It feeds on various molluscs, but also on worms and echinoderms (Ophiurans).

The eggs, which are 0.5 mm. in diameter, are deposited in small groups on stones, etc., to which they remain attached. While in the act of shedding the eggs the female is generally accompanied

by two or three males, which partly cover the female, so that a sort of copulation may be said to take place. The female does not rest over the eggs, and thus does not protect its brood. The development is direct, there being no pelagic larval stage.¹ It has been maintained that this species is a proterandric hermaphrodite, but this has not been confirmed. There is a possibility

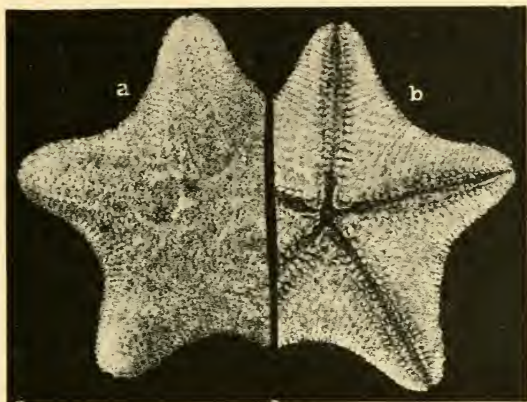


FIG. 56.—*Asterina gibbosa* ; dorsal (a) and oral side (b). Nat. size.
(From Koehler, *Faune de France*.)

that it may sometimes develop parthenogenetically (British south coast). The breeding season is in British seas May-June, in the Mediterranean somewhat earlier, April-May, more rarely already in March.

In British seas this species occurs along the south and west coasts as far north as Ross-shire, but not on the North Sea coasts. To the south it occurs as far as the Canaries, the Azores, and the Mediterranean. Bathymetrical distribution 0-ca. 125 m.

2. *Palmipes* Linck.

(Syn. *Anseropoda* Nardo.)

Body pentagonal or subpentagonal, flat and very thin. Along the rays a crest-like thickening. Spines very small, in close, paxillæ-like groups. No pedicellariæ. Papulæ confined to centre of disk and the mid-line of rays. Arms five or (in some Indo-Pacific species) many.

Only one species in British (and European) seas.

¹ Some species of *Asterina* have true pelagic larvæ of the *Brachiolaria* type.

1. *Palmipes membranaceus* Linck. (Fig. 57.)

(Syn. *Palmipes placenta* (Pennant) ; *Anseropoda membranacea* (Linck).)

Outline of body varying from perfectly pentagonal to sub-pentagonal with sides markedly concave.¹ The spine-groups arranged in fairly regular radiating series, those of the oral side slightly the larger. The adambulacral plates carry 5-6 slender

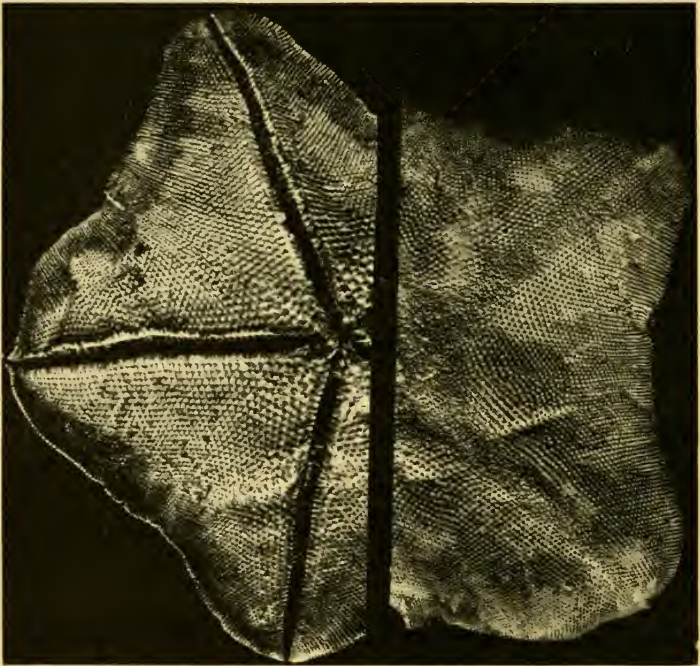


FIG. 57.—*Palmipes membranaceus*, oral and dorsal side. Somewhat reduced.

furrow spines, united in their basal part by a web ; on the outer surface there is a series of 4 small spines, likewise united at the base by a fine membrane. $R = \text{ca. } 1.5 r$. Reaches a size of ca. 20 cm. diameter. Colour in life red on the dorsal side, yellowish, generally with a very conspicuous band of red along the margin, on the ventral side.

It prefers sandy bottom, and appears to lie more or less buried in the sand. Its food consists mainly of crustaceans (amphipods, cumaceans, mysids, crabs, hermit-crabs), but it

¹ It appears that the sea-star is, to some degree, able to change the outline of its body.

devours also molluscs and echinoderms. No animal is known to feed upon it. Development unknown.

In British seas it occurs all round the southern, western, and northern coasts. In the North Sea it is known as far south as Hartlepool. It is distributed elsewhere from the Shetland Islands to the Mediterranean. Bathymetrical distribution ca. 10-200 m. Exceptionally (eastern Mediterranean) it goes down to 600 m.

A hybrid between this species and *Asterina gibbosa* has been found in the Mediterranean (*Palmipes Lobiancoi* Ludwig).

III. Family PTERASTERIDÆ

Dorsal side with paxillæ, covered over by a membrane (the supradorsal membrane), supported by the spines of the paxillæ and thus forming a roof over the whole dorsal side. In this membrane numerous small pores (spiracles) occur, which may be opened and closed spontaneously. In the middle of the dorsal side there is a larger opening, surrounded by five valves, supported by some larger spines. Along the edge of the disk usually a distinct fin-like membrane (the "actino-lateral" membrane), formed by a series of long, slender spines, connected by a membrane. Outside the adambulacral plates a series of segmental apertures opening into the supradorsal cavity, and guarded by a specialised opercular spinelet or papilla. No oral interradial plates.

The supradorsal cavity acts as a brooding pouch, the eggs developing here. There is thus no free, pelagic larval stage. In some species (e.g. *Pteraster obscurus*) the young sea-stars do not leave the cavity until they have reached a very considerable size—ca. 1.5 cm. diameter. The cavity likewise has a respiratory function; the water is sucked in through the segmental pores on the oral side and flows out mainly through the large central opening on the dorsal side, but also through the small spiracles in the supradorsal membrane (which were formerly erroneously stated to be the inhalent pores).

Two genera known to be represented in British seas, but two more may be expected to occur there also, viz. *Diplopteraster* Verrill, with the species *D. (Retaster) multipes* (M. Sars), known from Skagerrack to the Barents Sea, and from Greenland to 35° N. on the American coast; also in the Northern Pacific from the Bering Sea to Japan and California, and even recorded from S. Africa (ca. 100-1170 m.); and *Cryptaster* Perrier, with the species *Cr. personatus* Perrier (Azores, 2994 m.). These two are therefore included in the key to the genera, while not otherwise mentioned in the text.

Key to the genera of Pterasteridae known from or likely to be represented in the British seas.

1. Tube-feet in four rows *Diplopteraster* Verrill
 Tube-feet in two rows 2
2. Adambulacral spines united by a web so as to form a transverse comb (Fig. 58) 1. *Pteraster* Müll. & Troschel
 Adambulacral spines not united by a web 3
3. Mouth plates large, with spines on outer surface; fin-like membrane very conspicuous 2. *Hymenaster* Wyv. Thomson
 Mouth plates small, without spines on outer surface; fin-like membrane indistinct *Cryptaster* Perrier

1. *Pteraster* Müller and Troschel.

(Syn. *Hexaster* Perrier.)

Supra-dorsal membrane with muscles slightly developed, not forming a regular network. Adambulacral spines united by a web so as to form regular transverse combs (Fig. 58). Tube-feet in two series. Fin-like membrane usually well developed.

Two species are known from the British seas, but very prob-

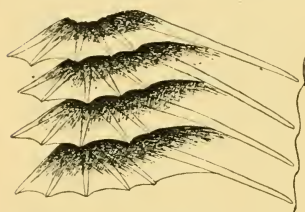


FIG. 58.—Adambulacral spines of *Pteraster militaris*. The long lateral spines support the fin-like membrane along the edge of the disk. $\times 8$. (From *Danmark's Fauna*.)

ably some of the following species will prove to occur there also, viz. *Pteraster pulvillus* M. Sars, known from the Scandinavian seas to Spitzbergen and the Siberian Sea, as also from Greenland to 42° N. on the American coast, and from the Bering Sea (ca. 15-400 m.); *Pt. reductus* Koehler, known from off the Azores (1846-2870 m.); *Pt. sordidus* Perrier, known from off Morocco (1139 m.), and *Pt. alveolatus* Perrier,¹ known from off the Azores

(4060 m.). These species are therefore included in the key. One more species may be mentioned, viz. *Pteraster* (*Hexaster*) *obscurus* Perrier, differing from all the other species in having 6 arms; as it is not known to the S. of Finmark in European seas, there is not much prospect of its occurring as far south as the British seas, but it is perhaps not excluded that it may be found in the cold area of the Faroe Channel. It is known elsewhere from Greenland to the Bank of Newfoundland, and from the Bering Sea (30-450 m.).

¹ Sladen ("Challenger" Asteroidea) refers this species to his genus *Marsipaster*; judging from the description and figures given by Perrier (*Échinodermes du "Travailleur" et du "Talisman"*), it seems to be a true *Pteraster*.

*Key to the species of Pteraster known from or likely to occur
in British seas.*

1. Rays 6 *Pt. obscurus* (Perr.)
- „ 5 2
2. Paxillæ with 2-5 spines 3
- „ „ 10-25 spines 5
3. Jaws with a pair of strong spines on the outer surface
 1. *Pt. militaris* (O. F. Müll.)
- Jaws without spines on the outer surface 4
4. Jaws with a small median projection (Fig. 59). 5 adambulacral spines. Fin-like membrane inconspicuous
 2. *Pt. personatus* Sladen
- Jaws without any median projection, the proximal edge straight, broad, with four strong spines on each side the mid-line and two smaller on the side-edge. 4 adambulacral spines. Fin-like membrane conspicuous *Pt. sordidus* Perr.
5. Spines along edge of jaw united by a web continuous across the mid-line ; no median keel or anterior prolongation ; a pair of large, robust spines on outer surface of jaws *Pt. pulvillus* M. Sars
- Spines along edge of jaw not united across the mid-line ; jaws with a median keel and a conspicuous anterior median prolongation ; spines on outer surface of jaws not very robust or (?) absent 6
6. Spines along edge of jaw equal-sized, those on each side united by a continuous web ; 2-3 similar spines on outer surface of jaw, close behind the marginal series. 6, farther out 5, adambulacral spines *Pt. reductus* Koehler
- Spines along edge of jaw not united by a continuous web along each side, but in two groups : two larger ones on each side of the median projection and four smaller ones on sides of jaw ; a single small spine on outer surface of jaw, close to the two larger anterior ones. 5 adambulacral spines
 - Pt. alveolatus* Perrier

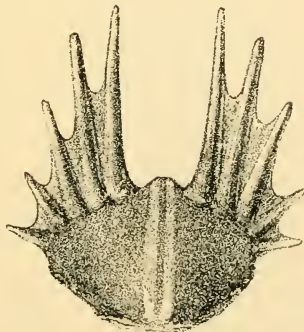


FIG. 59.—Jaw of *Pteraster personatus*. $\times 5$.
(After Sladen, *Echinod.*, S.W. Ireland.)

1. *Pteraster militaris* (O. Fr. Müller). (Fig. 60.)

Arms fairly long and slender. The paxillæ of the dorsal side with only 2-4 slender spines. Supra-dorsal membrane with numerous small calcareous bodies. Web connecting the spines along edge of jaws not continuous across the mid-line. Outer surface of jaws with two strong, outwardly directed spines. Only a very inconspicuous median projection of jaws. Adambulacral spines 5. The fin-like membrane fairly broad, partly visible from the dorsal side. $R. = ca. 2.5 r$. Reaches a size of 75 mm. R. Colour in life yellowish or yellowish-red.

Biology unknown, but it appears that ciliary currents play

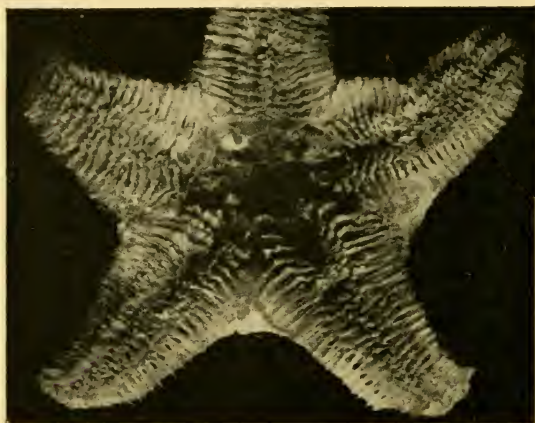


FIG. 60.—*Pteraster militaris*. Oral side. Nat. size.
(From *Danmark's Fauna*.)

some part in conveying detritus to the mouth, besides bringing water into the supra-dorsal cavity for serving the respiration of both the specimen itself and the young contained in the cavity.

In British seas it has been found only in the Faroe Channel (59° 37' N., 6° 49' W., 954 m., "Triton"), in the Inner Sound, Ross-shire, 36 m. ("Runa"), and on the Lousy Bank. Elsewhere distributed from the Skagerrack to Spitzbergen and the Siberian Sea, from Greenland to 40° N. on the American coast, and to Vancouver in the Northern Pacific; it is thus a circumpolar species. Bathymetrical distribution, 10-ca. 1100 m.

The variety *prolata* Sladen has somewhat longer arms, $R. > 3 r$; one of spines of the paxillæ much more robust than the others. The segmental apertures larger and the aperture papillæ broader

and more robust in their proximal portion than in the typical form. The three inner spines in the adambulacral comb form a line oblique to the ambulacral furrow. The actino-lateral spines very short, the membrane thus less conspicuous than in the typical form.

Only the single specimen known on which Sladen established this variety ($60^{\circ} 5' N.$, $6^{\circ} 21' W.$, 1094 m., "Triton"); the value of the variety is therefore rather problematic. At least the character of the inner adambulacral spines forming a line oblique to the ambulacral furrow is of no value as a distinguishing character of the variety, since this may be found in the typical form as well.

2. *Pteraster personatus* Sladen. (Fig. 61.)

Rays very broad at base and tapering to a fine extremity. Paxillæ with 3-4 or (in the central part of disk) more spinelets,

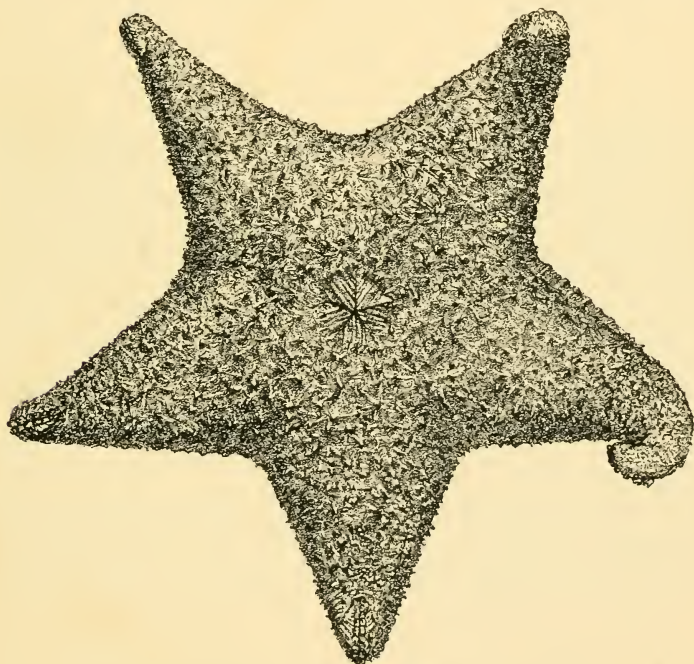


FIG. 61.—*Pteraster personatus*, dorsal side. Nat. size.
(From Sladen, *Echinod.*, S.W. Ireland.)

which appear very protuberant. Supra-dorsal membrane without calcareous bodies.¹ Web connecting the spines along edge of jaw

¹ Not stated directly in the original description; but at least they are not mentioned as present in the membrane.

not continuous across the mid-line; there is a small median projection on the jaws. No spines on outer surface of jaws. Adambulacral spines 5. The fin-like membrane inconspicuous, scarcely visible from the dorsal side. $R. = 2r$. Largest specimen known, 55 mm. $R.$ ¹ Colour in life unknown. Biology unknown.

Only two specimens known, taken at $51^{\circ} 1' N.$, $11^{\circ} 50' W.$, 750 fms. ("Flying Falcon"), and $51^{\circ} 15' N.$, $12^{\circ} 17' W.$, 673-893 fms. ("Helga"). The species has also been recorded from the Bay of Biscay (800 m., "Caudan"); but it seems doubtful whether the specimen obtained there is really *Pt. personatus*.

2. *Hymenaster* Wyv. Thomson.

Supra-dorsal membrane with numerous muscle fibres, which do not form a regular network. Adambulacral spines not united by a web to form regular transverse combs. Tube-feet in two series. Fin-like membrane usually very conspicuous.

Two species known from British seas, but four more may well be expected to occur there also, viz. *Hymenaster rex* Perrier, known from the Bay of Biscay to S. of the Canaries (ca. 1140-2300 m.); *H. Giboryi* Perrier, from off the Azores to off Portugal (ca. 1900-4275 m.); *H. roseus* Koehler, from off the Azores (ca. 1850-2100 m.), and *H. membranaceus* Wyv. Thomson, from S.W. of Cape Finisterre ($41^{\circ} 58' N.$, $9^{\circ} 42' W.$, 2025 m.). These species are therefore included in the key.

Key to the species of Hymenaster known from or likely to occur in the British seas.

- | | | | | | | | | |
|-------------------------------------|---|---|---|---|---|---|---|---|
| 1. Three furrow spines ² | . | . | . | . | . | . | . | 2 |
| Two " " | . | . | . | . | . | . | . | 3 |
2. Furrow spines slender, conspicuously decreasing in length from the proximal to the distal. Spines on outer surface of jaw slender. A large naked interradiial space extending more than halfway to the middle of the disk, the rays appearing straight-sided in almost their whole length . . . *H. rex* Perrier
- Furrow spines short, robust, equal sized. Outer spine on outer surface of jaw broad, compressed. Naked interradiial area less developed, rays gradually broadening proximally

H. membranaceus W. Th.

¹ The size, 70 mm. $R.$, given by Sladen appears to be a mistake (according to Farran).

² Sometimes three furrow spines may be found also in *H. pellucidus* and *giganteus*; in such cases the descriptions of these species must be consulted, as it would complicate the key too much to include such exceptional cases.

3. The long spines of the fin-like membrane (actino-lateral spines) do not join those of the neighbouring ray in the interradianal mid-line 4
 Actino-lateral spines joining those of the neighbouring ray in the interradianal mid-line 5
4. Paxillæ with 6-7 slender, delicate spines 1. *H. pellucidus* W. Th.
 „ „ 2-3 rather robust spines 2. *H. giganteus* Sladen
5. Jaws with 2 lateral spines ; rays appear as a petaloid figure on the dorsal side of disk *H. Giboryi* Perrier
 Jaws with 4 lateral spines ; rays do not appear as a petaloid figure on dorsal side of disk *H. roseus* Koehler

1. *Hymenaster pellucidus* Wyv. Thomson. (Figs. 62 ; 63, 1, 2.)

Body very flattened, only slightly rising towards the middle ; almost pentagonal, the ends of rays protruding only very little. Paxillæ with generally 6-7 (8) slender, delicate spines, scarcely protruding through the membrane. Valves around the central opening with 8-10 long, slender spines. Actino-lateral spines not

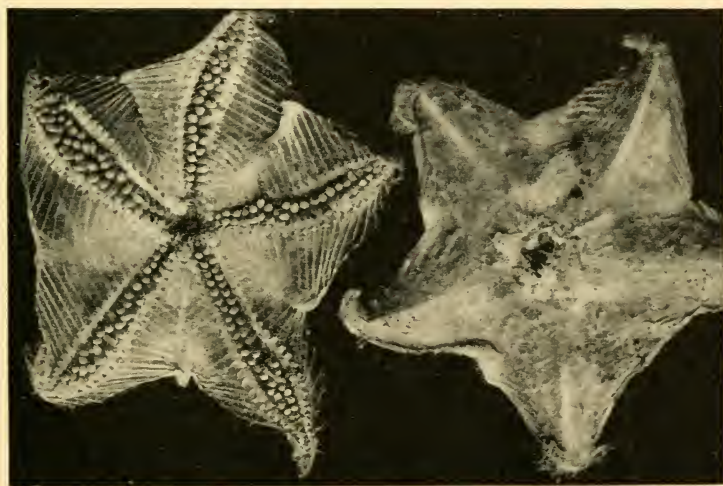


FIG. 62.—*Hymenaster pellucidus*, oral and dorsal side. Nat. size.

joining those of neighbouring rays in the interradianal mid-line. Jaws with a distinct median projection ; they are broadest behind the middle (Fig. 63, 2). Two, more rarely three, furrow spines, the proximal slightly the larger. Spines of segmental apertures enclosed by an oval sac of thin skin ; the spine itself broad in the basal half and with a single median prolongation

(Fig. 63, 1). Supra-dorsal and actino-lateral membrane very thin and pellucid, the whole structure of the animal being very delicate. $R. = ca. 1.5-2 r.$ Reaches a size of ca. 8 cm. diameter. Colour in life delicate rose, but varying to bluish-violet or yellowish-red. An Ophiuran has been found in the stomach of this species; otherwise nothing known of its food or biology.

In British seas this species is known only from the Faroe Channel, the cold area, 1045 m. ("Porcupine", "Michael Sars"). Otherwise distributed in the Norwegian Sea to Spitzbergen and east Greenland, and to the Siberian Sea. A record of its occurrence at the Azores evidently is due to a misidentification, the species being rather exclusively a cold-water form. Bathymetrical distribution ca. 15-2800 m.

2. *Hymenaster giganteus* Sladen. (Figs. 63, 3; 64.)

Body very flattened, but the rays, which are, through their conspicuously spiny character, well marked off from the naked interradii, have the appearance of being somewhat elevated. Outline nearly pentagonal, rays only slightly produced. Paxillæ with 2-3 rather robust spines, projecting through the supra-dorsal membrane, which gives the dorsal surface a coarsely spiny character. The valves around the central opening with ca. 8 fairly

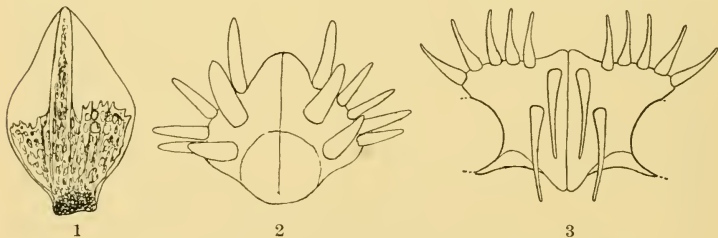


FIG. 63.—Spine of segmental aperture (1) of *Hymenaster pellucidus*; jaw of *H. pellucidus* (2); and *H. giganteus* (3); (the latter after Farran). 1. $\times 16$; 2. $\times 8$; 3. probably $\times ca. 6$ (enlargement not given by author).

robust spines. Actino-lateral spines not joining those of neighbouring rays in the interradii mid-line. Jaws with scarcely any median projection, the anterior margin being nearly straight; they are thus the broadest before the middle (Fig. 63, 3). Two, more rarely three, about equal sized furrow spines. The spines of the segmental apertures enclosed by a large, fleshy sack of almost rectangular outline; the spine itself very broad, its outer half consisting of numerous very fine, parallel rods, which gradually

disappear in the delicate meshwork of the basal part (Fig. 64). Supra-dorsal and actino-lateral membrane thick and fleshy, not

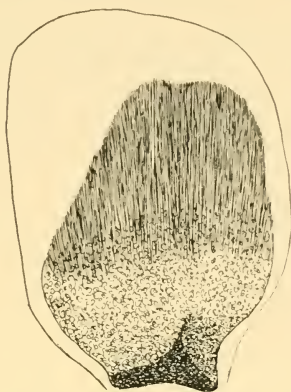


FIG. 64.—Spine of segmental aperture of *Hymenaster giganteus*. $\times 13$.

pellucid. R. = ca. 1.6 r. Reaches a very considerable size, ca. 26 cm. diameter. Colour in life deep blood-red.

Known only from off S.W. Ireland, 527-1350 m. ("Flying Falcon", "Helga").

IV. Family KORETHRASTERIDÆ

Dorsal side with paxillæ, formed by very long, fine spines, not covered by a supra-dorsal membrane. No fin-like (actino-lateral) membrane. No larger marginal paxillæ. No oral inter-radial plates. Spines of adambulacral plates forming together with those of lower marginals a single transverse series, not webbed. Rays mostly five.

This family forms a transition between the Pterasteridæ and Solasteridæ, having characters in common with both.

Only one genus represented in British and European seas.

1. *Korethraster* Wyv. Thomson.

Rays short. Plates of the dorsal side, carrying the paxillæ, polygonal or rounded, imbricating upwards. No papulæ between the dorsal plates. Spines of the paxillæ enclosed by a common skin-sheath, leaving the outer part free. Jaws with a strong spine on outer surface on each side of mid-line. One furrow spine. Adambulacral and marginal spines flattened, somewhat fan-shaped, made up of coalesced fine spines.

Only one species known with certainty from the British seas, but another species, *Korethr. setosus* Perrier, is very likely to occur there also. In fact it is probable that some young specimens taken by the "Helga" at 54° 17' N., 11° 33' W. (388 fms.), and 51° 20' N., 11° 41' W. (468-560 fms.), should be referred to this species.¹ The main characters distinguishing this species from *K. hispidus* are given in the key.

Key to the species of Korethraster known from or likely to occur in the British seas.

- | | |
|--|------------------------------|
| 4 spines to each side of jaws. No circle of larger plates in centre of disk | 1. <i>K. hispidus</i> W. Th. |
| 3 spines to each side of jaws. A circle of 5 larger plates in centre of disk | <i>K. setosus</i> Perrier |

1. *Korethraster hispidus* Wyv. Thomson. (Fig. 65.)

Paxillæ consisting of 6-10 long, very slender spines, with an oval thickening at the base. The plates nearest the centre of the disk not larger than the other dorsal plates. A rather deep furrow in the interradial mid-line without the usual polygonal

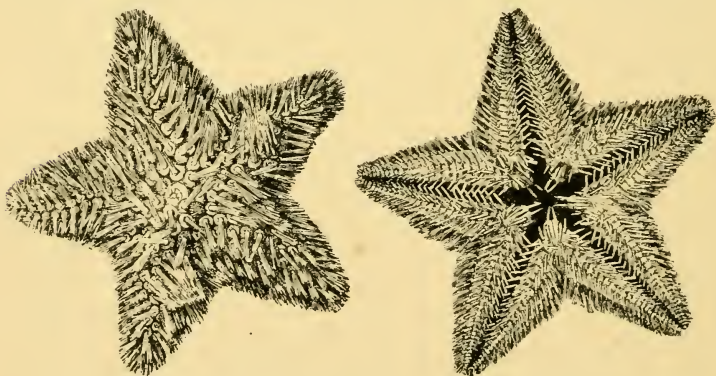


FIG. 65.—*Korethraster hispidus*. Slightly enlarged.
(After Sladen, "Challenger" Ast.)

plates; these furrows (which are concealed by the paxillæ) unite in the centre of the disk and thus divide the dorsal side into five segments. Jaws with four spines on each side, the spines on the outer surface strong, with the outer part hyaline. R = ca. 1.6-

¹ Cf. Farran, "The Deep-water Asteroidea, Ophiuroidea, and Echinoidea of the West Coast of Ireland" (*Fisheries, Ireland, Sci. Invest.*, 1912, vi. (1913), p. 23).

2·7 r. Apparently not reaching any large size ; largest size recorded : 24 mm. R. Colour in life pale yellow, the tube-feet darker yellow.

Biology and development unknown.

In British seas this species has been found only in the Faroe Channel (60° 14' N., 6° 17' W., 662 fms., "Porcupine"). It is known only from the cold area to Nova Zemlja, Spitzbergen, and East Greenland. Bathymetrical distribution, ca. 180-1150 m.

V. Family SOLASTERIDÆ

Disk rather large, arms fairly long, rounded ; five, or more often many arms. Skeleton of dorsal side reticulate ; more rarely larger, imbricating plates, carrying paxillæ. No supra-dorsal membrane ; no actino-lateral (fin-like) membrane. A single or double series of larger marginal paxillæ, representing the marginal plates. Oral interradiial plates present. Spines on adambulacral plates in two series at right angles.

Two genera represented in British (and European) seas.

*Key to the genera of Solasteridæ represented in British
(and European) seas.*

Arms many (7-15)	.	.	.	.	.	1. <i>Solaster</i> Forbes
Arms 5	.	.	.	.	.	2. <i>Lophaster</i> Verrill

1. *Solaster* Forbes.

Disk large ; rays many, 7-15, or even as many as 17. A single series of larger, marginal paxillæ, above which there may be a second series of distinctly smaller paxillæ.

The rather numerous species form two fairly distinct groups, one with short, the other with long paxillæ. These two groups are often regarded as separate genera, viz. *Solaster*, in a restricted sense, containing the species with short paxillæ, and *Crossaster* Müller and Troschel, containing the species with long paxillæ. It appears that the two groups differ also in their inner anatomy, *Crossaster* having an inner septum in each interradius, while this is lacking in *Solaster*. If this anatomical character proves to hold good for all the species, it would seem necessary to adopt the two genera. For the present it seems hardly sufficiently warranted.

Three species are known from the British seas, but besides these two more species will probably be found to occur there, viz. *Solaster glacialis* Danielssen and Koren, and *Solaster abyssicola* Verrill. The former is a purely Arctic form, known from East

Greenland to Spitzbergen and the Kara Sea, in 30-350 m. depth : on the Norwegian coast it has been found as far south as the Trondhjem Fjord. It may well be expected to occur also in the cold area of the Faroe Channel. *Solaster abyssicola* has been found on 45° 26' N., 25° 45' W., 3120 m. ("Michael Sars"), and may thus be expected to occur also in the deep water off Ireland. It is elsewhere known from off the N. American coast, in depths of ca. 1540-3800 m. These two species are therefore included in the key.

*Key to the species of Solaster known from or likely to occur
in the British seas.*

1. A single series of larger marginal paxillæ 2
 A double „ „ „ „ 4
2. The dorsal skeleton consists of narrow bars forming an open, irregular network (Fig. 66, 1) 1. *S. papposus* (Linn.)
 The dorsal skeleton scale-like or stellate 3
3. The dorsal skeleton scale-like, imbricating plates forming a very close covering (Fig. 66, 2), leaving only very small open spaces, containing single papulæ 2. *S. squamatus* Döderlein
 The dorsal skeleton stellate plates forming a quadrate mesh work (Fig. 66, 3); 3-7 papulæ in each interspace *S. abyssicola* Verr.
4. Paxillæ of dorsal side very close, flattened; mostly 4 large, conspicuous furrow spines *S. glacialis* Dan. and Kor.
 Paxillæ of dorsal side, more or less scattered, not flattened; mostly 2-3 small, inconspicuous furrow spines 3. *S. endeca* (Linn.)

1. *Solaster* (*Crossaster*) *papposus* (Linnæus). (Fig. 67; Fig. 66, 1.)

(Syn. *Solaster affinis* Koren and Danielssen.)

Rays 8-13, mostly 10-12. Dorsal skeleton (Fig. 66, 1) consisting of narrow bars forming an irregular reticulation, enclosing fairly large membraneous spaces in which several papulæ are found. Paxillæ large, broom-shaped, with rather long, slender spines; they are fairly distant, the covering of the dorsal side thus rather sparse. Marginal paxillæ large and conspicuous, in a single series. Furrow spines varying in number, mostly 3-5, long and slender. A transverse series of 5-9 somewhat longer spines on the adambulacral plates. $R = \text{ca. } 2r$. Grows to a very considerable size, up to ca. 340 mm. diameter. Colour in life rather variable, but mostly the disk is purplish-red, the arms whitish, with a broad red transverse band; more rarely it is uniformly purple on the dorsal side. Oral side whitish. It is, indeed, a splendid form, justly called "sun-star".¹

¹ "The Solasters are suns in the system of Sea-stars" (Forbes, *British Starfishes*, p. 110).

The variety *septentrionalis* Sladen is distinguished by having smaller and more numerous, closely crowded paxillæ, with ca.



FIG. 66.—Part of dorsal skeleton of *Solaster papposus* (1), *S. squamatus* (2), and *S. abyssicola* (3). 1, $\times 4$; 2, $\times 6$; 3, probably similar enlargement (not stated by author). (2. After Th. Mortensen, *Echinod. East Greenl.* 3. After Grieg, *Echinod. "Michael Sars"*, 1910.)

10-20 spinelets (in the typical form the paxillæ have up to ca. 40 spinelets). The papulæ are fewer, 1-3 in a group (5-10 or more

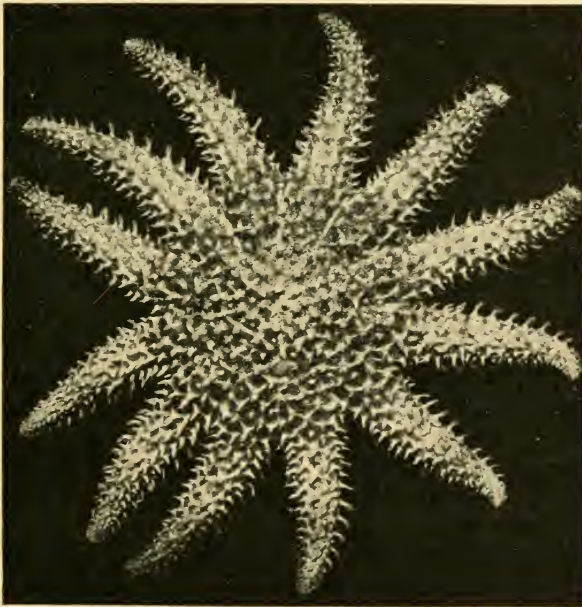


FIG. 67.—*Solaster (Crossaster) papposus*, dorsal side. Young specimen. Nat. size. (From *Danmark's Fauna*.)

in the typical form). The interradial areas are covered with small, rather crowded paxillæ (in the typical form with only 1-2

small paxillæ). Jaws with 9-10 spines in the superficial series (generally only 2-5 in the typical form). Rays 10. It appears that the variety *anglica* Döderlein is the same as *septentrionalis*, the only appreciable difference being that it has 12 arms, which is hardly a constant character.

The development is direct, without a Bipinnaria stage. The food consists mainly of other Echinoderms, especially sea-stars (*Asterias*) and sea-cucumbers (*Psolus*); Molluscs may, however, also form the chief part of its food, and it is reported to feed on oysters, thus doing harm on oyster banks. It is also recorded as eating Actinians; it is very voracious, and is able to devour sea-stars almost as large as itself.

In British seas this species appears to be common all round the coasts, from low-tide mark down to ca. 50 metres or more. It is elsewhere distributed all over the Arctic region, its southern limit in European seas being the Channel. On the American Atlantic coast it goes down to 40° N.; in the Pacific it goes down to Vancouver on the American, to the Ochotsch Sea on the Asiatic side. Bathymetrical distribution: 0-ca. 1200 m. The variety *septentrionalis* is recorded only from the Faroe Channel.

2. *Solaster squamatus* Döderlein.

Rays 9-11. Dorsal skeleton (Fig. 66, 2) consisting of imbricating plates forming a close, almost scale-like covering, leaving only very small spaces between them in which generally only a single papula is found. Paxillæ mainly like those of the preceding species, but rather smaller and of more uniform size. Marginal paxillæ in a single series. Furrow spines 5-7. A transverse series of mostly 8 spines on outer surface of adambulacral plates. $R = \text{ca. } 2.2\text{--}2.25 r$. Appears to reach not nearly so large a size as *S. papposus*, the largest size recorded being 107 mm. diameter. Colour in life orange-red, with yellowish-red paxillæ; yellowish-white on the oral side.

Biology and development unknown.

In British seas it has been found only in the cold area of the Faroe Channel, 1098 m. ("Michael Sars"). It is mainly, though not quite exclusively, a cold-water form, occurring as far north as Spitzbergen and East Greenland. Bathymetrical distribution: ca. 100-1160 m.

3. *Solaster endeca* (Linnæus). (Fig. 68.)(Syn. *Solaster intermedius* Sluiter.)

Rays generally 9-10, but their number may vary from 7 to 13. Paxillæ of dorsal side small, close-set, with short spines. Marginal paxillæ not very conspicuous; in two, often alternating, series, the upper much smaller than the lower ones. In larger specimens the lower marginal paxillæ are broad, comb-shaped. Furrow spines 2-3, rarely 4, small, almost concealed in the furrow; a transverse series of 6-8 rather short spines on outer surface of adambulacrals. $R = \text{ca. } 2.5 r$. Grows to a very considerable size,

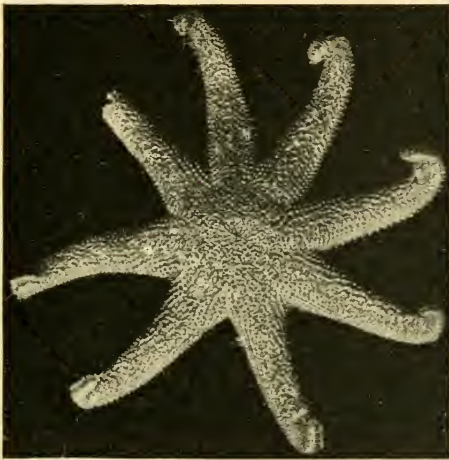


FIG. 68.—Young specimen of *Solaster endeca*, dorsal side. Nat. size.
(From *Danmark's Fauna*.)

up to ca. 400 mm. diameter. Colour in life a uniform yellowish-red or faintly violet.¹ Often the disk and the basal part of the rays are somewhat more strongly coloured.

Development direct, without a pelagic larval stage. Breeding season March-April. The food consists mainly of other echinoderms, and, like *S. papposus*, it is very voracious, being able to devour animals almost as large as itself.

In British seas it occurs from the south coast of Ireland all round the west, north, and east coasts, at least as far south as Cullercoats, whereas it is not known from the south coast of England or from the Channel.² It is common in the Scandinavian

¹ At the Atlantic coasts of N. America it is usually dark purple.

² The statement in Bell's *Catalogue Brit. Echinoderms* (p. 91) that it occurs "north of coast of France" does not seem warranted.

seas from the Sound to Spitzbergen; further it occurs from Greenland to Cape Cod on the American coast, and in the Northern Pacific from the Bering Sea to Vancouver. Bathymetrical distribution from the littoral region down to ca. 450 m.

2. *Lophaster* Verrill.

(Syn. *Sarkaster* Ludwig.)

Disk rather large, rays 5; a double series of well-developed marginal paxillæ.

Only one species known from British (and European) seas.

1. *Lophaster furcifer* (Düben and Koren). (Fig. 69.)

(Syn. *Solaster furcifer* Düben and Koren.)

Dorsal side rather closely covered by well-developed paxillæ more or less distinctly arranged in series. 3-4 furrow spines,

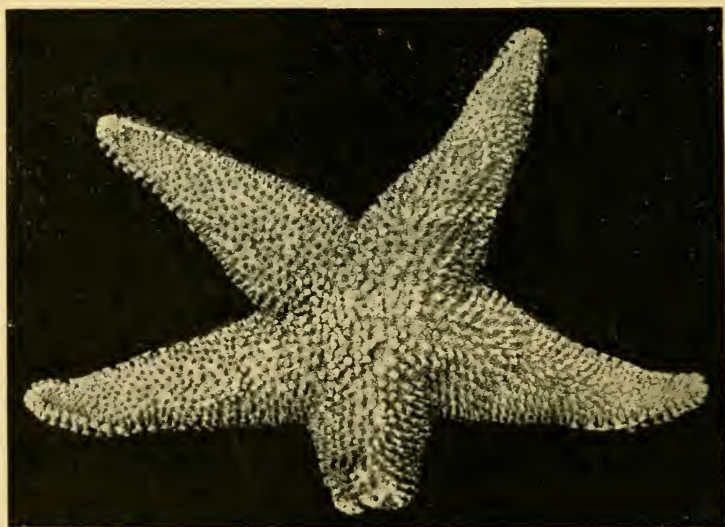


FIG. 69.—*Lophaster furcifer*. (After Grieg, *Asteroidea* "Mich. Sars", 1901-3.) Nat. size.

united by a thin web. Outer surface of adambulacral plates with a transverse series of 4-5 webbed spines. R = ca. 3 r. Grows to a size of ca. 125 mm. R, in Arctic regions, while farther south it scarcely reaches more than ca. 80 mm. R. Colour in life brick-red; the oral side whitish.

Biology and development unknown.

In British seas this species is known only from the cold area of the Faroe Channel ("Porcupine", "Michael Sars"), and from the Lousy Bank. It is known elsewhere from off Stavanger on the Norwegian coast to Spitzbergen and the Siberian Sea, and from Greenland to 40° N. on the American coast. The North Pacific forms *L. furcilliger* Fisher and *L. vexator* Fisher are scarcely specifically distinct from the Atlantic form. Bathymetrical distribution ca. 30-1350 m.

VI. Family ECHINASTERIDÆ

Disk very small ; arms five, long, slender, cylindrical, with no distinct limit between dorsal and oral side. Dorsal skeleton reticulate ; spines single or in small groups, not in the shape of paxillæ. No pedicellariæ. Tube-feet in two series.

Only one genus known from the British seas ; but another, *Echinaster*, is likely to be found off the south coast, the single European species of this genus, *Echinaster sepositus* (Retzius), occurring as far north as Brittany (Roscoff) (otherwise distributed as far south as Cape Verde ; very common in the Mediterranean ; bathymetrical distribution : from the coast down to 1060 m.).

Key to the genera of Echinasteridæ known from or likely to occur in the British seas.

Spines very fine, generally in small groups ; papulæ also on the oral side 1. *Henricia* Gray

Spines rather coarse, single ; no papulæ on the oral side
Echinaster Müll. and Troschel

1. *Henricia* Gray.

(Syn. *Cribrella* Lütken ; *Cribella* Forbes (non L. Agassiz) ;
Magdalenaster Koehler.)

Dorsal skeleton bearing numerous small spinelets either in groups or scattered along the ridges composing the reticulate skeleton. Marginal plates more or less distinguishable. Ambulacral plates with one or more spinelets placed deep within the narrow ambulacral furrow. Papulæ numerous, occurring also on the oral side.

Two species are known from the British seas, but three more may be expected to occur there also, viz. *Henricia biscayensis* (Koehler) (Bay of Biscay, 1410 metres ; only a single specimen known, taken by the "Caudan") ; *Henricia caudani* (Koehler) (Bay of Biscay, 650 metres ; only a single specimen known,

“Caudan”), and *H. abyssalis* (Perrier) (off Morocco and the Azores, ca. 1100-2165 metres). These species are included in the key.

The species of this genus are mostly exceedingly variable and the limits of the species very hard to fix; hybridisation probably accounts for a good many of the intermediate forms. It is by no means certain that all the above-named five Atlantic species can be maintained; especially it may be expected that a richer material will prove *H. caudani* to be identical with *H. abyssalis*, the difference in the furrow spines given in the key as distinguishing these two species being probably due more to different mode of description than to really existing differences.¹

*Key to the species of Henricia known from or likely to occur
in the British seas.*

1. One or more distinct series of larger plates outside and parallel to the adambulacral plates. Spines on the outer surface of the adambulacrals abruptly smaller than the furrow spines . . . 2
Generally no distinct series of larger plates outside the adambulacrals. Spines of the outer surface of adambulacrals gradually diminishing in size from the furrow spines outwards, without any abrupt difference in size . . . 1. *H. sanguinolenta* (O. F. Müll.)
2. Rays much swollen in the basal part, and here on each side with 4-5 regular longitudinal series of plates, above the two series following the adambulacrals . . . *H. biscayensis* (Koehler)
Rays cylindrical; no distinct longitudinal series of plates above the series following the adambulacrals . . . 3
3. Rays exceedingly slender, cylindrical; only one distinct series of larger plates outside the adambulacrals . . . 2. *H. abyssicola* (Norman)
Rays not especially slender, tapering; 2-3 distinct series of larger plates outside the adambulacrals . . . 4
4. Skeleton of dorsal side very close; 1-2 furrow spines and four similar spines outside these . . . *H. caudani* (Koehler)
Skeleton of dorsal side more open; 5-6 furrow spines, united by a small web so as to form a small comb . . . *H. abyssalis* (Perrier)

1. *Henricia sanguinolenta* (O. F. Müller). (Fig. 70.)

(Syn. *Cribrella sanguinolenta*; *Echinaster sanguinolentus* (O. F. Müll.); *Echinaster scrobiculatus* Dan. and Koren; *Cribrella oculata* (Pennant) Forbes; *Magdalenaster arcticus* Koehler.)

Rays more or less slender, tapering. Spines on the adambulacral plates generally forming a single transverse series, diminish-

¹ The author has not had the opportunity of examining specimens of these two species, or of *H. biscayensis*.

ing gradually in size outwards. Plates outside the adambulacrals generally small and not very regularly arranged in longitudinal or transversal series. The number of spines in the groups on the dorsal side rather variable. $R=4-5r$. Colour varying from blood-red to yellow. Reaches a very considerable size, up to 10 cm. length of rays.

In the large specimens the rays may be very much swollen and broad; such forms have been described as *Magdalenaster arcticus* and referred to the family Cryasteridæ. But all intermediate stages towards the usual slender-rayed form occur, and these large specimens, which occur mainly in the Arctic seas, evidently belong to *Henricia sanguinolenta*.

The variety *curta* Norman is described as having much shorter, broader, and flatter arms than the typical form; also their

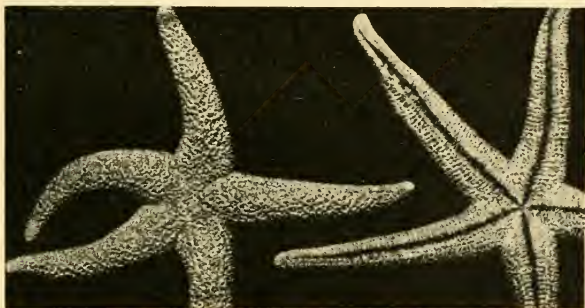


FIG. 70.—*Henricia sanguinolenta* (O. Fr. Müller). Young specimen. Dorsal and oral side. Nat. size. (From *Danmark's Fauna*.)

texture is stated to be less firm. It rarely exceeds 2 inches in diameter. Colour pale yellow. It was found between tide-marks in Balta Sound. Renewed examination of fresh material is necessary for deciding whether this form can be maintained as a distinct variety.

This is a brood-protecting species. The mother attaches herself by means of the tube-feet in the distal part of the arms to a vertical rock wall, the underside of a stone or the like, then raises the proximal part of the arms and the disk so as to form a closed cavity, into which the eggs are extruded; these lie free in the cavity, not directly attached to the mother. The development takes ca. three weeks, during which time the animal does not feed. The embryos do not get any nourishment from the mother, but subsist entirely on the contents of yolk in the eggs. If the sea-star be removed from the eggs or the larvæ these develop further in

the normal way ; sometimes also both eggs and embryos are found free, pelagic. There is no Bipinnaria stage. The number of eggs is ca. 500. The breeding season is February-April (May).

It is not known upon what this sea-star normally feeds. It is generally found empty. It has been observed in the mounted position over a *Mytilus*, and thus may be supposed at least occasionally to feed on mussels. A semiparasitic copepod, *Astrochæres Lilljeborgi* Boeck, is usually found on its skin, moving swiftly among the spines, but holding very tightly with its feet ; it has sucking mouth parts, and doubtless sucks its nourishment from the sea-star, like a sort of louse. Also *Dendrogaster*, a very much transformed and reduced cirripede, is known to live entoparasitic in this species.

In British seas this species is rather common all round the coasts, excepting perhaps on the Channel coasts. It is found in all depths from between tide-marks down to ca. 1000 metres or probably more. It is otherwise distributed southwards to the Bay of Biscay and the Azores ; further in the Scandinavian seas, from the Baltic to the Arctic region, Iceland, Greenland, and the North American coast down to Cape Hatteras ; also in the North Pacific down to Washington and the Kuriles. It is stated to occur down to a depth of ca. 2450 metres.

2. *Henricia abyssicola* (Norman). (Fig. 71.)

(Syn. *Cribrella sanguinolenta* var. *abyssicola* Norman ;

Cribrella oculata, var. *cylindrella* Sladen.)

Rays very long and slender, nearly cylindrical. Spines on the adambulacral plates more or less distinctly arranged in three transverse series ; those on the outer surface of the adambulacral plates much smaller than the furrow spines, no gradual passage existing from the longer furrow spines to the short outer spines. One, or in the proximal part of the rays two, longitudinal series of larger plates parallel to the adambulacral series. Spines of the dorsal side very fine, in fairly dense groups. R = ca. 6r. Colour in life creamy-white to saffron-yellow. Appears to reach only a small size, ca. 5 cm. R.

Biology unknown.

In British seas this species has been found off S.W. Ireland (" Helga ") and in the warm area of the Faroe Channel

("Triton"), in depths of ca. 930-1400 metres. It is not known from other localities.



FIG. 71.—*Henricia abyssicola*, oral and dorsal side. Nat. size.

III. Order. FORCIPULATA Perrier.

Marginal plates generally inconspicuous, not forming a vertical edge to the disk; no sharp limit between dorsal and oral side of disk and arms. Spines of dorsal side single, or in groups, which may be arranged in longitudinal series. Tube-feet mostly in four series, always with a sucking disk. Crossed and straight pedicellariæ present. Rays five or many.

Four families of this order are known from the British seas; a fifth, the family *Pedicellasteridæ*, is almost certain to be represented there also, though not hitherto recorded. This family is included in the key; the genera and species of this family to be expected in the British seas are briefly mentioned (p. 129).

Key to the families of the Forcipulata known from or likely to be represented in British seas.

1. Tube-feet in two series ¹ 2
- Tube-feet in four series at least in the proximal part of rays . . . 3
2. Rays more or less constricted at the base; dorsal skeleton of rays restricted to the proximal part. Long and slender marginal spines enclosed in a bag of skin, covered with crossed pedicellariæ. No straight pedicellariæ . I. Fam. *Brsingidæ*

¹ Also one species of the *Zoroasteridæ*, *Prognaster Grimaldii*, has the tube-feet in the main biserial in the whole length of the ray, while otherwise in this family the tube-feet are distinctly 4-serial in the proximal part of the arms. In its whole appearance this species is otherwise a typical *Zoroasteroid*, with very long, slender arms, and could never be mistaken for being a *Brsingid* or a *Pedicellasterid*.

Rays not constricted at base; dorsal skeleton present in the whole length of the rays. Both crossed and straight pedicellariæ

Fam. *Pedicellasteridæ*

3. Dorsal skeleton irregular, reticulate; spines single

IV. Fam. *Asteriidæ*

Dorsal skeleton larger, fairly regularly arranged plates, covered with groups of small spines or grains 4

4. Adambulacral plates of two alternating sorts; dorsal side with small spines. Tube-feet generally in two series in the distal part of rays II. Fam. *Zoroasteridæ*

Adambulacral plates of one kind only; dorsal side with small grains or spines. Tube-feet in four series, usually to the end of the rays III. Fam. *Stichasteridæ*

I. Family BRISINGIDÆ

Rays mostly numerous, rarely only (5) 6-7, long and slender, more or less restricted at the base and sharply defined against the small disk. Dorsal skeleton of rays restricted to their proximal part. Adambulacral and marginal spines long and slender, enclosed in a bag of skin, covered with crossed pedicellariæ. No straight pedicellariæ. Tube-feet in two series.

The sea-stars belonging to this family are mainly deep-sea forms, some of them, at least, strongly phosphorescent. They are exceedingly brittle, the arms generally breaking off at the base, where there is a non-muscular articulation between the first and second adambulacrals and the upper part of the second and third ambulacrals (not in the genus *Freyella*). It is therefore very difficult to get complete specimens, and often all the arms break off and the small disk, which looks like a small ring when seen from the oral side, is found isolated in the trawl. Some species have the habit of folding their arms together against the oral side, when coming unhurt to the surface, like a splendid flower closing itself up.

Division by autotomy occurs in an Australian species, otherwise the development is unknown.

Three genera are represented in the British seas, but two more may well be expected to occur there also, viz. *Colpaster* Sladen, the single species (and only specimen) known, *Colpaster scutigerula* Sladen having been found S.W. of the Canaries (25° 45' N., 20° 14' W., ca. 2750 m.), and *Freyella* Perrier, of which the following five species are known from the East Atlantic: *Freyella spinosa* Perrier (19°-42° N., 20°-23° W., 2320-4060 m.); *Fr. Edwardsi* Perrier (Bay of Biscay, S. of Canaries, 1760 m.); *Fr. sexradiata* Perrier (Bay of Biscay, Azores, 4020-4700 m.); *Fr. recta* Koehler (Azores, 3465 m.);

and *Fr. tuberculata* Sladen (S. of Canaries, between Cape Verde and Ascension, 2350-2400 m.).

These two genera therefore are included in the key. (A key to the *Freyella* species is given below, p. 128.)

Key to the genera of Brisingidæ known from or likely to be represented in the British seas.

1. Disk and genital region of arms with numerous, conspicuous papulæ 1. *Odinia* Perrier
- No papulæ on either disk or arms 2
2. Dorsal skeleton of arms in the shape of raised arches, bearing small spinelets 3
- Dorsal skeleton of arms a uniform armour of plates, not in the shape of raised arches 4
3. Genital organs numerous, arranged in a series along either side of each ray 2. *Brisinga* Asbjörnsen
- Only one pair of genital organs in each ray 3. *Brisingella* Fisher
4. An unpaired, conspicuous, shield-shaped oral interradiial plate separates the first adambulacrals; 7 arms *Colpaster* Sladen
- No unpaired oral interradiial plate separating the first adambulacrals. 6 (5)-13 arms *Freyella* Perrier

1. *Odinia* E. Perrier.

Arms numerous (13-19), coalesced for a short distance at their base. Dorsal skeleton of genital region of arms a mosaic of plates, more or less distinctly arranged in arcs, which carry long spines forming series across the arm. Disk and arms with numerous papulæ. One pair of genital organs to each arm. Jaws laterally widened so as to separate almost completely the ambulacral furrow from the mouth region.

One species, *Odinia pandina* Sladen, known from the British seas. Three more species have been recorded from the East Atlantic and are likely to occur also in the British seas, viz. *Odinia robusta* E. Perrier (Bay of Biscay, S. of the Canaries, ca. 880-1750 m.); *O. semi-coronata* E. Perrier (S. of the Canaries, Denmark Strait, ca. 1000-1435 m.); and *O. elegans* E. Perrier (S. of the Canaries, ca. 880-1445 M.). It would seem not improbable that *O. robusta* and *semi-coronata* are in reality identical with *O. pandina*; from the description it does not appear clearly which characters distinguish them from that species. No key, therefore, can be given of these species, only reference to the original description in Perrier's *Échinodermes du "Travailleur" et du "Talisman"*. *O. elegans* is a small form, distinguished from *O. pandina* through the transverse series of spines on the arms being only slightly developed; there are three complete series

in the outer part of the genital region, beyond which the series are rudimentary, only two spines on each side. The basal part of the arms with only a few irregularly scattered, small spines.

The species of this genus appear to prefer a rocky bottom.

1. *Odinia pandina* Sladen.¹ (Fig. 72.)

Plates of disk each with 2-3 spinelets, ca. 2 mm. long; spines

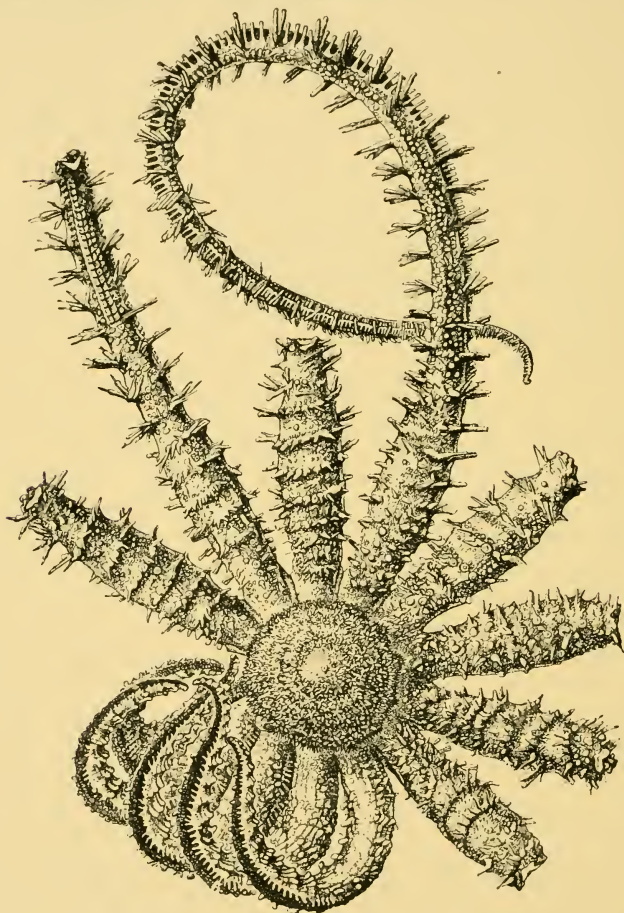


FIG. 72.—*Odinia pandina*; somewhat reduced. (After Wyv. Thomson, *Depths of the Sea*.)

of arms forming 5-6 arcs across the genital region, beyond which

¹ In case it is ultimately proved definitely that *O. robusta* and *semi-coronata* are identical with *O. pandina*, the name to be used is *semi-coronata*, which is the older and the type species of the genus *Odinia*.

the arcs are incomplete, with 4-6 spines of 6-8 mm. length on each side of arm. They are invested in thick membranous sheaths crowded with minute crossed pedicellariæ. Adambulacral plates, each with a single spine 4-5 mm. long, directed downwards; it is compressed in its outer part, truncate, chisel-like. On account of the shortness of the adambulacral plates these adambulacral spines form a rather close fringe along each side of the adambulacral furrow. No true furrow spines. Colour in life unknown. $R = \text{ca. } 15 r$.

Biology and development unknown.

Hitherto known with certainty only from the Faroe Channel, $60^{\circ} 7' \text{ N.}, 5^{\circ} 21' \text{ W.}, 900 \text{ m.}$; bottom temp. 1.1° C. ("Lightning"); $60^{\circ} 6' \text{ N.}, 8^{\circ} 14' \text{ W.}, \text{ca. } 790 \text{ m.}$; bottom temp. 5.5° C. ("Porcupine").

2. *Brisinga* Asbjörnsen.

Arms numerous (10-13), not coalesced at their base. Dorsal skeleton of arms in the shape of raised arches or ribs, bearing small spinelets. Along the sides of the arms a single series of very long, slender spines. No papulæ on disk or arms. Genital organs small, in a series along each side of arm. Jaws not laterally widened so as to close the ambulacral furrow from the mouth space. First pair of adambulacral plates joining in the interradial mid-line.

Only one species, *Br. endecacemos* Asbjörnsen, known from the British seas, but possibly another may be found there, namely *Br. hirsuta* Perrier, found at $44^{\circ} 7' \text{ N.}, 10^{\circ} 16' \text{ W.}, 2030 \text{ m.}$ ("Talisman"). It is very imperfectly known; only a pair of small arm fragments have been found. It is characterised by having numerous arcs, one to each adambulacral plate, set with a close series of pointed spinelets, among which are scattered large pedicellariæ. In the proximal part of the arm these spines cover the whole surface, the arcs being indistinct. It is uncertain whether this species belongs to *Brisinga* or *Brisingella*.

1. *Brisinga endecacemos* Asbjörnsen. (Fig. 73.)

Arms almost constantly 11. The raised arches numerous, 20-30, continuing to about the middle of the arm or even a little beyond, each set with a series of very small spinelets. There is an arch only to every second or third adambulacral plate. The skin between the arches set with similar small spinelets, attached to small, isolated plates. Madreporite elevated, partly covered

with spines. Pedicellariæ of two sorts, larger and smaller ; no pedicellariæ on the disk. Colour in life a splendid red, the under-side whitish. Grows to a very considerable size, to ca. 370 mm.



FIG. 73.—*Brisinga endecacnemos*. Two of the arms in regeneration. (After G. O. Sars.) Ca. $\frac{1}{2}$ size. (From *Danmark's Fauna*.)

length of arms, with a diameter of disk of ca. 26 mm. When complete probably the most magnificent of all sea-stars.

It prefers rocky bottom. Development unknown.

In British seas this species has been found in the Faroe Channel ("Porcupine"), and off S.W. Ireland ("Helga"), in

ca. 360-1800 m. It is elsewhere distributed from the Trondhjem Fjord to the Cape Verde Islands. Bathymetrical distribution ca. 200-2000 m.

3. *Brisingella* W. K. Fisher.

Differs from the genus *Brisinga* mainly by the first pair of adambulacral plates not joining in the interr radial mid-line, and by having only one pair of large genital organs to each arm.

Only one species known to occur in the British (and East Atlantic) seas.

1. *Brisingella coronata* (G. O. Sars).

(Syn. *Brisinga coronata* G. O. Sars.)

Number of arms varying, 9-13. The raised arches only ca. 12 (9-15), confined to the proximal one-third of the arms, each carrying a series of fairly strong spines. The skin between the ribs naked, but with groups of pedicellariæ, these groups continuing to the end of the arm. Madreporite without spines. Pedicellariæ small, all of the same size, occurring also on the disk. Colour in life a beautiful red. Reaches a very considerable size, up to ca. 400 mm. R., with a diameter of disk of hardly 30 mm.

It lives on muddy bottom; feeds on all sorts of smaller animals, especially Foraminifera. The breeding season is in summer; development unknown, but the rather large, yolky eggs indicate that it has probably a direct development, without a pelagic larval stage.

In British seas this species has been found off S.W. Ireland and at the Rockall Bank ("Porcupine", "Flying Fox"), in depths of ca. 360-1800 m. It is elsewhere distributed from the Trondhjem Fjord to the Azores and the Cape Verde Islands; it also occurs in the Mediterranean, both in the western and eastern parts. Its bathymetrical distribution is ca. 100-2600 m.

[*Freyella* E. Perrier.]

(Syn. *Freyellidea* Fisher.)

Although no representative of this genus has been found in the British seas as yet, there can scarcely be any doubt that it will ultimately be found there. It may therefore be desirable to give a diagnosis of this important genus and a key to the species, and also a figure of one of the species (Fig. 74).

Dorsal skeleton of rays consists of polygonal plates, forming a close armour; these plates may be arranged more or less distinctly in transverse series, but never form raised arches as in

Brisinga. There are no papulae on disk or arms. No unpaired, shield-shaped interradial plate on the oral side, separating the first adambulacrals. Rays 6-13, very exceptionally (*Fr. sexradiata*) only 5. The articulation between first and second adambulacrals or between the upper end of second and third ambulacrals plates not ligamentous, syzygial. One pair of genital organs to each ray.

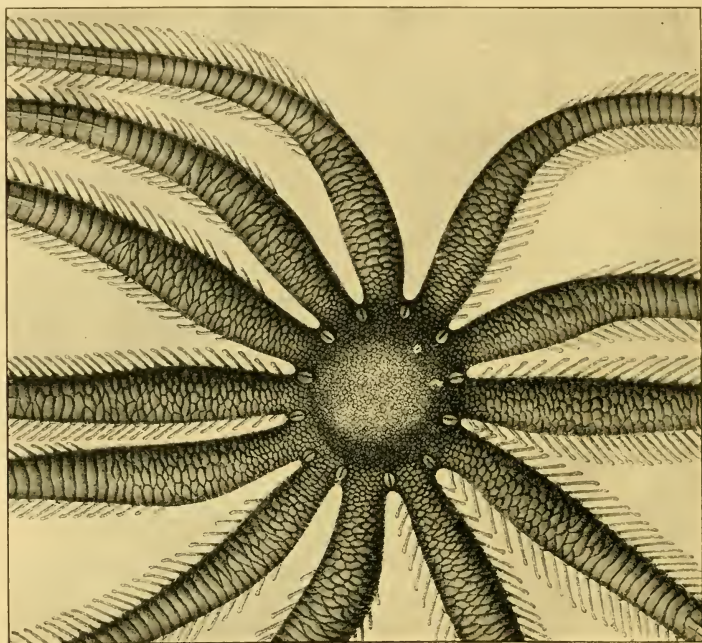


FIG. 74.—*Freyella Edwardsi*. (After Koehler, *Monaco*, Fasc. xxxiv.)

Possibly some of the east Atlantic species really belong to the genus *Freyellaster* Fisher, which is distinguished from *Freyella* in having a ligamentous (syzygial) articulation between the first and second adambulacrals and between the upper end of second and third ambulacrals, and by having numerous genital organs in each ray. The species *spinosa* and *sexradiata*, however, are known with certainty to belong to the genus *Freyella* (Fig. 74).

Key to the East Atlantic species of the genus Freyella.

- | | |
|---|---|
| 1. Arms 11-13 | 2 |
| Arms 6 (5)-8 | 3 |
| 2. A conspicuous naked dorsal interradial plate at the base of each pair of arms. No furrow spine; outer adambulacrals in proximal part of arm widened at the point. <i>Fr. Edwardsi</i> E. Perrier | |

- No naked dorsal interradi al plate. A horizontal furrow spine separating the consecutive pairs of tube-feet. Outer adambulacral spine not widened *Fr. spinosa* E. Perrier
3. Arms 8 ; no furrow spine. Skeletal plates in proximal part of arms irregular polygonal *Fr. recta* Kohler
- Arms 6 (exceptionally 5) 4
4. Skeletal plates in proximal part of arms regular, elongate, hexagonal. No furrow spine *Fr. tuberculata* Sladen
- Skeletal plates in proximal part of arms irregular polygonal ; a small furrow spine *Fr. sexradiata* E. Perrier

The distribution of these species is given above, p. 122.

One other species of *Freyella* exists in the North Atlantic (taken at 62° 10' N., 19° 36' W., ca. 2060 m., "Thor"). It is a large, coarse, apparently undescribed form with 11-13 arms, resembling *Fr. Edwardsi* in having the proximal adambulacral spines widened and in lacking a furrow spine ; but it has no naked dorsal interradi al plate at base of arms ; the plates of the dorsal side of arms with numerous small spines. (In *Fr. Edwardsi* these are single or only a few together.)

[Family PEDICELLASTERIDÆ]

Rays five or more, short, tapering, or more elongate, slender, not restricted at the base. Dorsal skeleton of arms reticulate, forming very large, mostly rectangular meshes ; it continues to the end of the arm. Adambulacral and marginal spines not especially elongate. Both crossed and straight pedicellariæ present. Tube-feet in two series.

Sometimes the tube-feet may be somewhat crowded so as apparently to stand in more than two series in the proximal part of the arm ; but it is only apparently so ; a closer inspection will show that they stand only in two series.

Two genera are represented in the N.E. Atlantic. A third genus, *Gastraster* Perrier, referred by Perrier to this family, is here placed in the family Stichasteridæ. A fourth genus, *Lytaster* Perrier, with the only species, *L. inæqualis* Perr., is, according to information from Prof. W. K. Fisher, only a young *Coscina asterias tenuispinus* (Lamk.).

Key to the East Atlantic genera of Pedicellasteridæ.

1. Lateral and dorsal spines rather elongate, slender, carrying at their base or higher up a wreath of pedicellariæ. Arms 8 or more *Coronaster* Perrier
- Lateral and dorsal spines not elongate, not with a wreath of pedicellariæ, these latter only occurring scattered. Arms 5-8 *Pedicellaster* M. Sars

Of the genus *Coronaster* two species are known from the East Atlantic ; viz. *Coronaster Parfaiti* E. Perrier (off Cape Verde Isl., 150 m.) and *C. Antonii* E. Perrier (Bay of Biscay, off Cape Spartel, Morocco ; ca. 400-700 m.). The two species are thus distinguished :

Rays 11 ; the five inner adambulacrals with 3 spines in a transverse series ; wreath of pedicellariæ high up on the spines

C. Parfaiti Perrier

Rays 9 ; all adambulacrals with 2 spines, the one somewhat behind the other, sometimes almost forming one longitudinal series. Wreath of pedicellariæ at the base of the spines

C. Antonii Perrier

The position of the wreath, at the base or higher up on the spine, is scarcely a reliable difference ; the position at the base of the spine may rather be due to preservation, as is the case in some of the Asteriidae.

The species of this genus are splendid sea-stars, somewhat recalling *Solaster*, and may reach a considerable size (R.=190 mm. in *C. Antonii*).

Of the genus *Pedicellaster* two species are known from the Atlantic, viz. *Pedicellaster typicus* M. Sars (Scandinavia, from 60° N. to Spitzbergen and the Kara Sea, and from West Greenland to 42° N. on the American coast ; ca. 20-1130 m.), and *P. sexradiatus* E. Perrier (Bay of Biscay to Cape Verde and the Azores ; ca. 600-3465 m.). The two species are thus distinguished :

Rays 5 ; spines of dorsal side distinctly smaller than the adambulacral spines ; no series of spines along the adambulacrals

P. typicus M. Sars

Rays 6 ; spines of dorsal side fairly long and slender, as long as the adambulacral spines. A series of spines parallel to the adambulacrals, giving the appearance that there are 3 spines in each transverse series *P. sexradiatus* E. Perrier

They are small forms, scarcely exceeding 40 mm. length of arms, very much resembling young specimens of *Asterias*.

While *P. typicus* has large eggs and, therefore, probably direct development, without a pelagic Bipinnaria stage, *P. sexradiatus* has numerous small eggs and may be expected to have a typical pelagic larva. In fact, there is much reason for assuming that the so-called "*Stellosphaera mirabilis*" Koehler and Vaney (which is only a *Brachiolaria* in metamorphosis) really is the larva of *Pedicellaster sexradiatus* ; this probably also holds good for the *Brachiolaria hibernica* Gemmill, which appears to be identical

with the "*Stellosphæra mirabilis*". The fact that this *Brachiolaria hibernica* was found 50 miles W. of Ireland would then indicate that *Pedicellaster sexradiatus* does occur in the British seas.

II. Family ZOROASTERIDÆ

Rays 5, long and slender, stiff, tapering; not restricted at base and not sharply defined against the small disk. Dorsal skeleton larger plates arranged in regular longitudinal series, generally covered with small spines. The series of plates along the mid-line of arms, the "carinals", especially prominent, often with a conspicuous spine. Disk with a fairly conspicuous rosette of larger plates. Adambulacral plates mostly of two alternating sorts, one projecting into the furrow as a vertical keel, the other retracting, not keeled. A projecting plate on one side of the furrow corresponds to a retracting plate on the other side. Tube-feet mostly with only a small sucking disk, generally only in two series in the distal part of arm, mostly in four series in the proximal part. Straight pedicellariæ usually present; no crossed pedicellariæ.

Only one genus, *Zoroaster* Wyv. Thomson, has been recorded from the British seas, but very probably also the second genus of the family known from European seas, *Prognaster* E. Perrier, will prove to occur there; the single species (and only specimen known) of this genus, *Prognaster Grimaldii* E. Perrier, was found at 41° 40' N., 29° 04' W., 2870 m. ("Hirondelle").

Key to the genera of Zoroasteridæ known from or likely to occur in the British seas.

All the adambulacrals projecting into the ambulacral furrow, and with a vertical keel	<i>Prognaster</i> Perrier
Only every second adambulacral projecting into the furrow, and with a vertical keel	1. <i>Zoroaster</i> Wyv., Thomson

1. *Zoroaster* Wyv. Thomson.

Plates of arms arranged in distinct, regular, longitudinal rows; they are covered with skin-clad spinelets, and most of them bear an enlarged spine. Ventro-lateral plates in three to five series; lower and upper marginals about equal sized. Straight pedicellariæ present. Mouth very deep. Sucking disk of tube-feet small.

Only one species known from British seas, but another, *Zoroaster longicauda* (Perrier) (Syn. *Prognaster longicauda* Perrier), is likely to occur there also (known from Bay of Biscay, Azores, Cape Verde, ca. 1260-4250 m.).

Key to the species of Zoroaster known from or likely to occur in the British seas.

Arms moderately long, $R = \text{ca. } 6-12r$, and rather stout; marginal plates rectangular, leaving only very small and inconspicuous spaces for the papulae between them. Tube-feet in four rows nearly to end of arm . . . 1. *Z. fulgens* Wyv. Thoms.

Arms very long, $R = \text{ca. } 16r$, and slender. Marginals obtusely cross-shaped, leaving fairly large and conspicuous membranous spaces for the papulae between them. Tube-feet in four rows only in the proximal (ca. $\frac{1}{4}$) part of arms

Z. longicauda (E. Perr.)

1. *Zoroaster fulgens* Wyv. Thomson. (Fig. 75.)

(Syn. *Zoroaster trispinosus* Koehler; *Z. diomedæ* Verrill;
(?) *Z. Ackleyi* Perrier.)

Rays moderately long, rather stout, subcylindrical. Carinals with a median elevation to which is attached a coarse, conical spine. Upper marginals also usually with such a spine, and in

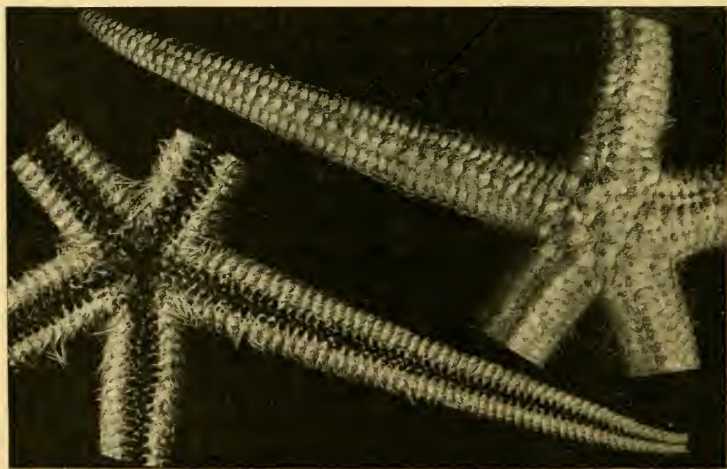


FIG. 75.—*Zoroaster fulgens*, oral and dorsal side. Somewhat reduced.

the larger specimens often some of the intermediate plates on the arms, as also some plates on the disk, carry similar spines. (These spines are easily rubbed off by rough handling in the trawl or otherwise.) All the plates otherwise covered with small, uniform granules, which carry short, membrane-covered spinelets.

The plates between the adambulacrals and lower marginals usually with 1-3 long, upwardly directed, appressed spines, forming slightly oblique lines. The prominent adambulacrals with four moderately long spines forming a transverse series, the innermost one with ca. 2-5 pedicellariæ attached to the point; the non-prominent adambulacrals have no spines within the furrow. Reaches a very considerable size, up to ca. 160 mm. R. The relative length of arms is subject to considerable variations: $R = \text{ca. } 6-12 r$; it appears that older individuals have proportionally the longer and more slender arms. Colour in life varying from pink or yellowish to white. The living specimens are rather slimy.

Biology and development unknown.

In British seas this species has been found in the Faroe Channel and off S.W. Ireland, where it appears to be very common in depths of ca. 800-1200 m. It is distributed all over the North Atlantic, from Iceland to S. of the Canaries, and on the American side from off Newfoundland to Brazil. The bathymetrical distribution is ca. 730-2470 m.

It would seem not improbable that among the numerous specimens taken by the "Helga" off S.W. Ireland there are really two different species, viz. besides the typical *Z. fulgens* another form with more slender arms and with more numerous carinal plates (a specimen of the typical form of $R = 93$ mm. having 55, one of 94 mm. R of the slender form having 93 carinals). The author having had no opportunity of examining this slender form, can only call attention to the said differences, as recorded by Farran (*Op. cit.* p. 21); perhaps these slender armed specimens were really *Z. longicauda*.¹

III. Family STICHASTERIDÆ²

Rays mostly 5, short or of medium length, tapering, not restricted at the base and not sharply defined against the disk. Dorsal skeleton of arms fairly large, mostly imbricated plates arranged in more or less regular longitudinal rows, leaving only small spaces between them for the papulæ. They are covered

¹ It is figured by Farran (*Op. cit.*, Pl. I. 3) under the name *Zoroaster fulgens*, var. *Ackleyi*.

² This family is not acknowledged by W. K. Fisher in his latest works, the genus *Neomorphaster* being made the type of a subfamily Neomorphasterinæ, and the genera *Stichastrella* and *Gastraster* being referred to the subfamily Asteriinae, both of the family Asteriidae. Also the Pedicellasteridae are regarded as a subfamily only of the Asteriidae.

with small granules. Tube-feet in four regular rows, mostly to the end of the arms. Both crossed and straight pedicellariæ present, scattered. Adambulacral plates all alike. Adambulacral spines never carrying pedicellariæ.

Three genera represented in British (and European) seas.

*Key to the genera of Stichasteridæ known from the British
(and European) seas.*

1. Lower marginals with a series of larger flattened spines, forming a conspicuous fringe along sides of arms 3. *Gastraster* Perrier¹
No fringe of larger spines along sides of arms 2
2. Disk plates forming a regular, conspicuous rosette ; dorsal skeleton of arms in very regular longitudinal and transverse series
1. *Neomorphaster* Sladen
Disk plates not forming a distinct rosette ; dorsal skeleton of arms not in very regular longitudinal and transverse series
2. *Stichastrella* Verrill

1. **Neomorphaster** Sladen.

(Syn. *Calycaster* Perrier.)

Disk plates forming a regular, conspicuous rosette of larger (primary) plates. Dorsal skeleton of arms arranged in very regular longitudinal and transverse rows (recalling *Zoroaster*). Adambulacral plates with two spines. Tube-feet 4-serial, but may become biserial towards the ends of the arms.

This genus is transitional between the families *Zoroasteridæ* and *Stichasteridæ*. Only one species known in British and European seas.

1. *Neomorphaster talismani* E. Perrier. (Fig. 76.)

(Syn. *Neomorphaster eustichus* Sladen ; *Calycaster monæcus* E. Perrier.)²

Rays 5, tapering to a point, flattened on the under side. Along the adambulacrals in the proximal part of arms a double series of plates carrying a comb of (two) three divergent thick, somewhat flattened spines, as long as the adambulacral ones, forming

¹ This genus is referred by Perrier and Fisher to the family *Pedicellasteridæ*, but in the opinion of the present author rather belongs to the *Stichasteridæ*.

² The name *Neomorphaster Parfaiti* Perrier used for this species in Koehler's *Échinodermes du "Caudan"* is a misprint.

longitudinal series. No larger spines on the marginal or dorsal plates, but only granules and pedicellariæ. The plates along the mid-dorsal line of arms rather prominent, like the carinals of *Zoroaster*. Disk slightly sunk, well defined against the interradii by a pair of larger, rounded plates. A straight pedicellaria may be found rather regularly on the inner edge of every second adambulacral plate. $R=4.5\ r$. Reaches a size of ca. 80 mm. R. Colour in life orange.

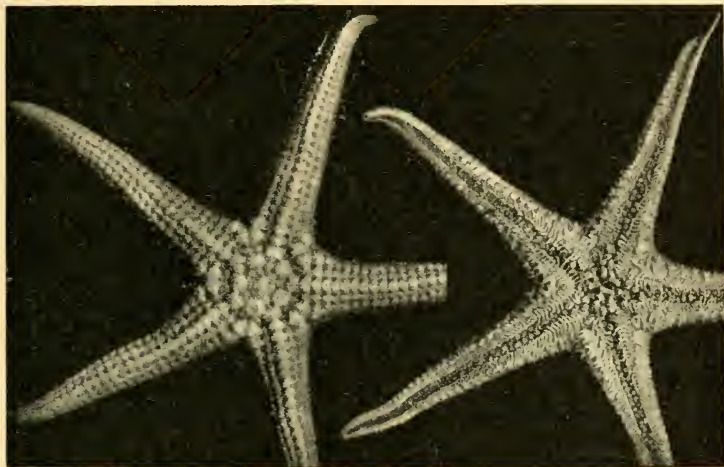


FIG. 76.—*Neomorphaster talismani*, dorsal and oral side. Nat. size.

Biology and development unknown.

In British seas this species has been found off S.W. Ireland ($51^{\circ} 1' \text{ N.}$, $11^{\circ} 50' \text{ W.}$, 1350 m.; Green). It is elsewhere known from the Bay of Biscay, the Azores, and off the Moroccan coast. Bathymetrical distribution, ca. 400-2000 metres; exceptionally it has been found at a depth of 5413 m.

2. *Stichastrella* Verrill.

Disk plates not forming a regular rosette. Dorsal skeleton of arms less distinctly arranged in longitudinal or transverse series; each plate covered with a group of granules or short, truncate spines. Adambulacral plates with usually three spines in a transverse series. Tube-feet 4-serial to end of arm.

Only one species known from British and European seas.

1. *Stichastrella rosea* (O. Fr. Müller). (Fig. 77.)

(Syn. *Asterias*, *Asteracanthion*, *Stichaster roseus* (O. F. Müll.) ;
Cribella rosea Forbes ; *Stichaster arcticus* Dan. and Kor.)

Rays 5, round, gently tapering. Adambulacral spines forming 2-3 close series along each side of the ambulacral furrow. Outside these some shorter spines, likewise arranged in longitudinal series ; they form the transition to the grains of the dorsal side. Madreporite large and distinct, surrounded by a circle of grains. The straight pedicellariæ on the sides of the ambulacral furrows. The crossed pedicellariæ on the dorsal side, especially on the sides of arms. $R = \text{ca. } 7 r$. Reaches a size of ca. 15 cm. R. Colour in life orange-reddish or more yellowish.

Development only partially known, but, in any case, it has a



FIG. 77.—*Stichastrella rosea*. Dorsal side. Somewhat reduced size.
 (From *Danmark's Fauna*.)

true pelagic larva, probably with a Brachiolaria stage. The breeding season is August-September. About its food nothing is known, but it appears that ciliary currents do not have the rôle of carrying food to the mouth. It appears to prefer a sandy bottom.

In British seas this species occurs all around the coasts, excepting the Channel coasts. It is otherwise known only from the Bay of Biscay to Lofoten on the Norwegian coast. It is a shallow-water species occurring from ca. 4 m. down to ca. 430 m.

In deeper water, ca. 400-1300 m., off S.W. Ireland, a form of *Stichastrella* has been found ("Helga") which differs from the typical *St. rosea* in having stouter and shorter arms— $R = \text{ca. } 5.8 r$.—and in the arrangement of the dorsal skeletal plates being more regular than is usually the case in *St. rosea*. As there seem, however, to be no other constant differences it can scarcely represent another species, and is designated as var. *ambigua* Farran.

3. *Gastraster* Perrier.

Disk plates not forming a regular rosette. Dorsal plates of arms arranged in very regular longitudinal rows. Lower marginals carry a series of large, flattened spines, forming a conspicuous fringe along sides of arms. Adambulacral plates with two spines. Tube-feet 4-serial in proximal part of arm, biserial farther out.

Only one species known.

1. *Gastraster margaritaceus* Perrier. (Fig. 78.)

Rays 5, somewhat tapering, flattened on the under side. Dorsal plates of arms each carrying a group of 6-7 short rounded spines, among which isolated crossed pedicellariæ occur. In the spaces between the plates single papulæ. Marginal spines

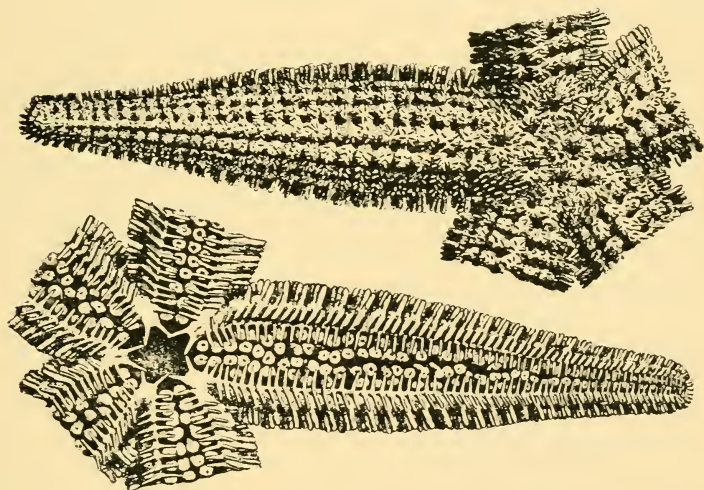


FIG. 78.—*Gastraster margaritaceus*, oral and dorsal side. Somewhat enlarged. (After Perrier, *Échinod. "Travailleur" et "Talisman"*.)

arranged in oblique series of 3-4, the outer, proximal one being the largest. The adambulacral spines rather long and slender, each two forming a transverse series oblique to the ambulacral furrow. Between the adambulacrals and the marginals some small straight pedicellariæ; such are also found within the ambulacral furrow, especially in the proximal part. Colour in life unknown. Not known of a larger size than 17.5 mm. R.

Biology and development unknown.

One small specimen, 12 mm. R., found at 53° 07' N., 14° 50' W.,

738-900 m. ("Helga"), (12. v. 1905; not hitherto recorded). The species has been found elsewhere only in the Bay of Biscay and off the Azores, 938-1225 m. ("Talisman").

IV. Family ASTERIIDÆ

Rays usually 5 or 6, of medium length, tapering, generally not sharply defined against the disk. Dorsal skeleton of arms mostly irregular, reticulate; spines single, forming more or less distinct longitudinal series. Generally both crossed and straight pedicellariæ. Tube-feet in four series.

Three genera of this family are represented in the British seas, but one more may well be expected to occur there also, viz. *Sclerasterias* Perrier, with the species *Sclerast. Guernei* Perrier, known from the Bay of Biscay, 240-300 m. The species *Sclerast. neglecta* Perrier (Syn. *Stolasterias*, *Stylasterias neglecta*; *Asterias Edmundi* Ludwig), recorded also from the Bay of Biscay, and from the Mediterranean, is scarcely to be distinguished from *Sclerast. Guernei*). Further, there is perhaps a possibility that the genus *Coscinasterias* Verrill also may be represented on the southern coasts by the species *Coscinast. tenuispinus* (Lamarck); it occurs from the S.W. coast of France to Cape Verde, the Azores, and the Mediterranean, and also at the Bermudas Islands, in the littoral region, down to 40 m. The two said genera, therefore, are included in the key.

Key to the genera of the family Asteriidae known from or likely to occur in the British seas.

1. Adambulacral spines alternating, one and two; carrying pedicellariæ 2
 Adambulacral spines in a regular single or double series; not carrying pedicellariæ 3
2. Papular areas large, each with numerous small papulæ
 1. *Asterias* Linnæus
 Papular areas small, each with few, larger papulæ
 2. *Leptasterias* Verrill
3. Adambulacral spines in a regular double series ("diplacanthid"); mid-dorsal and marginal plates forming regular series, each with a single, fairly large spine, surrounded by a wreath of pedicellariæ *Sclerasterias* Perrier
 Adambulacral spines in a regular single series ("monacanthid") 4
4. Rays 6 or more; one series of spiniferous ventro-lateral plates. Generally with 2 (3) madreporites. Propagates normally by self-division *Coscinasterias* Verrill
 Rays 5; one series of ventro-lateral plates, hidden by skin, not spiniferous; no propagation by self-division. Only 1 madreporite 3. *Marthasterias* Jullien

1. *Asterias* Linnæus.(Syn. *Asteracanthion* Müll and Troschel.)

Rays 5 or 6, rather short, broad, tapering; disk fairly large. Dorsal skeleton of arms forms an open, irregular network, leaving rather large, naked spaces containing several small papulæ. Spines of dorsal side in a more or less regular series along the mid-line of arms and on the marginal plates, otherwise not arranged in distinct longitudinal series. Adambulacral spines alternating one and two, though not quite regularly. Pedicellariæ are generally attached to the inner adambulacral spines. Genital openings on the dorsal side.

Only one species known from British and European seas.

1. *Asterias rubens* Linnæus. Common Crossfish. (Fig. 79.)

(Syn. *Asterias violacea* O. Fr. Müller; *Asteracanthion rubens* Müll. and Troschel; *Uraster rubens*; *U. violacea* Forbes; *Asterias Murrayi* Bell.)

Dorsal skeleton as a rule faintly developed, the dorsal skin being therefore rather soft. Adambulacral spines in the proximal part of arm fairly regularly alternating one and two. Externally to the adambulacral spines generally 3-4, in young specimens only 2, ventro-lateral spines in an oblique series (Fig. 81, 2); they are slightly larger and more robust than the adambulacral ones. The marginal plates generally each with 2-3 somewhat smaller spines, forming longitudinal series along the sides of the arm. Spines along the mid-line of arm in a more or less distinct series, sometimes double; as a rule they are not much larger than the other spines of the dorsal side. Pedicellariæ usually scattered over the whole dorsal side, both sorts intermingled; as a rule not specially gathered round the spines. Their number varies exceedingly, from very numerous to very scarce. On the oral side almost exclusively straight pedicellariæ, especially attached to the inner furrow spines (Fig. 26, 7). Also on the sides of the adambulacral plates, within the furrow, pedicellariæ are often found. R. mostly = ca. 4.5 r., more exceptionally only 3.5 r. or as much as 7 r. Reaches a very considerable size, up to ca. 26 cm. R. (these very large specimens chiefly in deeper water).

Colour varying from reddish-brown to dark violet; specimens from deeper water as a rule more light coloured, a pale reddish-yellow. The dark violet specimens look very different from the

reddish ones and have been regarded as a separate species (*Ast. violacea*) ; but as no definite distinguishing character appears to exist, and all transitions in the coloration may be found even in one and the same locality, they are no doubt all one and the same very variable species. Abnormalities with 4 or 6, or even 7-8 (9), arms, and also such as have two- or three-branching arms, are not rare.

The breeding season is in summer, from April to July, or perhaps even later. The larva has a Brachiolaria stage (Fig. 28, 4) ; it may in places occur in enormous numbers in the plankton. The young sea-stars may especially be found in numbers on the *Zostera* leaves, feeding mainly on young *Mytilus*. The rate of

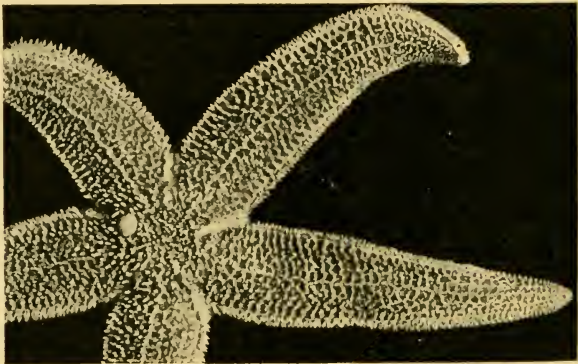


FIG. 79.—*Asterias rubens*. Dorsal side. Nat. size.
(From *Danmark's Fauna*.)

growth depends on the amount of food available ; with rich food they grow very rapidly (cf. p. 48). Sexual maturity is reached in the course of one year.

It is a very voracious animal. Its food consists especially of molluscs ; larger prey it digests outside the body by evaginating the stomach over it. (Concerning the way in which it opens larger mussels, cf. above, p. 47, Fig. 29.) But it also eats crustaceans (especially barnacles), worms, echinoderms, even specimens of its own species, indeed almost everything eatable, living or dead. It does considerable damage to oyster-cultures, though it would appear that it cannot by itself open the larger, undamaged oysters. At Plymouth it is reported to feed mainly on *Pecten opercularis*. Fishes it cannot take, except when caught in nets ; but it may well cause some damage to the fishes, injuring them with its spines on being pressed together in

the trawl. It is eaten itself only by other sea-stars (*Solaster*, *Luidia ciliaris*). In places it is used for manure (or, at least, formerly was thus used ; *teste* Forbes).

A semi-parasitic Copepod, *Scottomyzon gibbosum* Scott, of the family Asterocheridæ, lives on this sea-star. Also another crustacean, *Podalirius typicus* Kröyer, of the family Caprellidæ, is often found on it, though probably not parasitic on it, as is evidently the former.

The varieties *attenuata* and *gigantea* of Hodge can scarcely claim recognition as separate varieties. Likewise the *Asterias Murrayi*¹ of Bell is scarcely anything but a form, hardly distinct enough to be recognised even as a variety, of this very variable species. Possibly also *Asterias hispida* Pennant belongs rather to this species than to *Leptasterias Mülleri*.

In British seas this species is exceedingly common all round the coasts. It is elsewhere distributed from the White Sea and Iceland (but not Greenland) down to the Senegal coast. It is not found in the Mediterranean, except in the oyster basins at Cette, where it has evidently been accidentally introduced. It can stand rather brackish water and therefore may go rather far into the Baltic. Its bathymetrical distribution is from the upper tide-mark down to ca. 400 m., or more exceptionally as much as 650 m.

2. *Leptasterias* Verrill.

Differs from the genus *Asterias* mainly in the dorsal skeleton of arms being somewhat more robust, leaving only small naked spaces, containing each only one or a few papulæ. Openings of the genital organs on the ventral side.²

1. *Leptasterias Mülleri* (M. Sars). (Fig. 80.)

(Syn. *Asterias*, *Asteracanthion Mülleri* (M. Sars); *Asterias hispida* Pennant.)

Rays 5, of medium length, tapering, often somewhat swollen at base and rather distinctly marked off from disk. Adambulacral spines as a rule for some distance on the proximal part of arms in a single series, farther out alternating one and two, or sometimes only apparently so, alternatingly bending inwards and outwards. The spines outside the furrow spines (the ventro-lateral

¹ An excellent figure of this *Asterias Murrayi* is given in Bell's *Catalogue Brit. Ech.*, Pl. XII. 1.

² The openings of the genital organs are as a rule very difficult to observe from the outside, as in most sea-stars.

spines) single (Fig. 81, 1); the marginal plates likewise with a single spine each, forming two regular series along sides of arms. Spines of the dorsal side generally only indistinctly arranged in



FIG. 80.—*Leptasterias Mülleri*. Nat. size.
(From *Danmark's Fauna*.)

longitudinal series, more distinctly in younger specimens. They may be rather distinctly knob-shaped, especially those along the mid-dorsal line. The pedicellariæ mainly collected around the spines; the straight ones generally only at the ambulacral furrows. $R = \text{ca. } 4\text{--}7\text{ } r$. Reaches scarcely a larger size than $\text{ca. } 100\text{ mm. } R$. Colour in life a faint red or violet on the disk and proximal part of arms; whitish towards the end of arms.

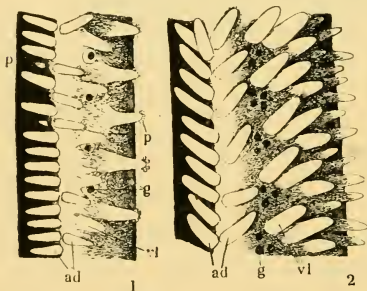


FIG. 81.—Part of right side of ambulacral furrow of *Leptasterias Mülleri* (1) and *Asterias rubens* (2). $\times 8$.
(From *Danmark's Fauna*.)

ad, Adambulacral (furrow) spines; g, Pores of papulae; p, Pedicellariæ; vl, Ventrolateral spines.

The breeding season is in early spring (March - April). It protects its brood; the eggs are kept around the mouth in the space produced by the mother by putting its arms together and raising its back. The embryos develop here, without any free-swimming larval stage; the young ones do not leave their mother until the three first pairs of tube-feet have appeared. During the whole time required for development the mother does not take

any food. (In a nearly related species, *Leptasterias groenlandica* (Steenstrup), the eggs are taken into the stomach itself and undergo their whole development there.)

In British seas this species (generally recorded under the name *Asterias hispida*) is known from S.W. Ireland (Dingle Bay—new record), the Irish Sea, the Clyde, Rona, and from the Shetland Islands to Dogger Bank. Very probably it is common all round the coasts, excepting, perhaps, the South coasts. It is not known to the south of the British seas; towards the north it occurs on the Scandinavian coasts, to Spitzbergen and the Siberian Sea; further at Iceland, Greenland, and the N. American coast, down to 44° N. Probably it occurs also in the Bering Sea, being in that case doubtless circumpolar. Its bathymetrical distribution is from the tide limit down to ca. 800 m.

3. *Marthasterias* Jullien.

Rays 5, rather long; dorsal skeleton of arms fairly regular, especially the median series of ossicles. Spines rather strong, surrounded by a conspicuous wreath of pedicellariæ. No ventrolateral spines. Adambulacral spines in a very regular single series (“monacanthid”), not carrying pedicellariæ.

Only one species in British and European seas.

1. *Marthasterias glacialis* (Linnæus). (Fig. 82.)

(Syn. *Asterias*, *Uraster*, *Asteracanthion*, *Stolasterias glacialis* (Linn.); *Asterias madeirensis* Stimpson; *Asterias spinosa* Pennant; *Marthasterias foliacea* Jullien.)

Disk small, fairly well defined against the long, narrow, gently tapering arms. Spines along the mid-dorsal line of arms and on the marginals very conspicuous and forming regular longitudinal series (upper marginals with one, lower marginals with two spines), giving the arms (especially on dried specimens) a rather angular appearance. Between the mid-dorsal and the marginal spines another more or less regular series of spines may be found; but these spines may be lacking completely. The furrow spines rather slender. The crossed pedicellariæ very numerous, forming a thick cushion at the base of each of the larger dorsal and marginal spines; straight pedicellariæ scattered on the dorsal side; also on the adambulacrals, within the furrow, but not on the furrow spines. $R = \text{ca. } 5.9 r$, the length of arms being relatively much larger in large than in small specimens. Reaches

a very considerable size, up to 35 cm. R. Colour in life yellowish, orange, reddish, or greenish.

It is a very voracious animal, which feeds on all sorts of larger marine organisms, living or dead : fishes, crustaceans, echinoderms, but especially molluscs ; it is reported as doing harm on the oyster banks. At Plymouth it appears to feed mainly on *Pecten opercularis*.

It is very apt to throw off its arms when hurt or otherwise in poor condition ; they regenerate very easily. But it does not

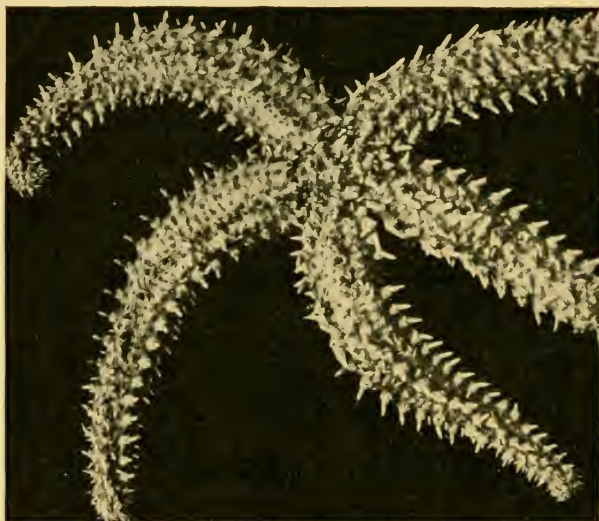


FIG. 82. — *Marthasterias glacialis*. Somewhat reduced in size.
(From *Danmark's Fauna*.)

propagate by self-division, as does the somewhat similar, more southern, species *Coscinasterias tenuispinus*.

The larva very much resembles that of *Asterias rubens* ; the characters by which to distinguish these two larval forms are unknown. The breeding season is the summer ; in the Mediterranean it appears to have two yearly breeding seasons, summer and winter.

In British seas this species occurs all round the West coast, and to Plymouth on the South coast ; from the British North Sea coasts it is not recorded, while elsewhere it has been recorded both from the northern and southern part of the North Sea. It is elsewhere distributed from Finmark and Iceland down to the Azores and the Cape Verde Islands, and also the Mediterranean.

Its bathymetrical distribution is from the littoral region down to ca. 180 m.

III. Class. BRITTLE-STARS OR OPHIUROIDS

(OPHIUROIDEA)

Free-living echinoderms with a round, flat, disk-shaped body from which proceed 5 (rarely more) thin, articulate arms, well marked off from the disk. Neither intestinal nor, as a rule, genital organs pass into the arms. No open furrow along the ventral side of the arms.¹ Tube-feet in small pores in two series along the under-side of arms. Mouth turning downwards. Intestinal organs a simple sac-shaped stomach, without cæca or anal opening.

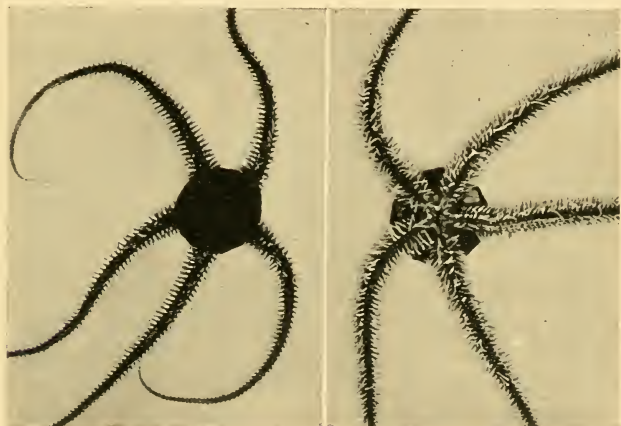


FIG. 83.—A Brittle-star (*Ophiocomina nigra*), dorsal (left figure) and ventral side (right figure). Nat. size. (From *Danmark's Fauna*.)

The *body* of the Ophiuroids (Fig. 83) is small, disk-shaped, rarely exceeding a pair of centimetres in diameter; only in *Gorgonocephalus* it may be up to ca. 10 cm. in diameter. The *arms*, which are always well defined against the disk, are long, often many times exceeding the diameter of the disk, slender, as a rule very flexible. A few forms of the order of the Euryalids have

¹ Only the palæozoic Ophiuroids had an open ambulacral furrow. It has been maintained that a recent form, *Ophioteropsis* Bell, is lacking ventral plates, thus being a very primitive form, related to the palæozoic Ophiurids with open ambulacral furrow, and this form has played an important rôle in classification. But it is only a gross mistake; the form in question has in reality well-developed ventral plates and is nothing but the well-known *Ophiothela tigris* Lyman of the family Ophiotrichidæ.

branched arms. The number of arms is almost constantly 5, though 4- and 6-armed specimens may occur as abnormalities. Only very few species have normally 6 or more arms. The arms are provided with an internal skeleton, very much resembling a vertebral column, made up of originally paired pieces, the ambulacral plates, which coalesce to a single vertebra-like piece provided with articular surfaces and processes for the attachment of the muscles. The articular surfaces are of two different types. In the Euryalids they are hour-glass-shaped, vertical on the proximal, horizontal on the distal end of the vertebra; this articulation makes possible a vertical movement and the rolling in of the arms. In the other Ophiurids it is a more complicated system of knobs and grooves, fitting into one another and in the main allowing only horizontal movements of the arms. A few forms, however, of this group (like *Ophiopholis* and *Ophiothrix*, as also some Ophiacanthids) are also able to roll in their arms against the ventral side.

Both disk and arms are, as a rule, covered by a dermal skeleton, consisting of fairly regular plates, the shape and arrangement of which are of eminent importance for classification (Fig. 84). On the dorsal side of the disk the more important are a pair of larger plates off the base of each arm, the radial shields; very often there are some larger, regularly arranged plates in the middle of the disk, one central plate and around this one or two alternating circles, each with five plates. These *primary plates* are nearly always to be observed in young specimens, but in most species they become indistinct with age. In some forms the dorsal side is covered by granules or small spines or by a thick, naked skin. On the under-side of the disk the interradial areas generally have the same sort of covering as the dorsal side. A single or double comb of papillæ may occur at the base of the arms.

The arms are mostly covered by regularly arranged plates, four to each joint or segment, viz. one *dorsal*, two *lateral* (or side) *plates*, and one *ventral plate*. The ventral and dorsal plates form a regular longitudinal series along the ventral and dorsal mid-line of the arms. The first ventral plate and the proximal dorsal plates differ somewhat in shape from the following, and towards the end of the arm the plates again gradually assume another shape. In the descriptions of these plates under the various species the description always refers, unless specially stated, to the plates of the inner part of the arms, where they have their normal, not modified, shape. Some Ophiuroids have the arms covered

by a thick, soft skin, which entirely conceals the plates. To the outer edge of the lateral plates the *arm spines* are articulated; as a rule they are more or less erect, outstanding, or (in the Euryalids) directed downwards, but they may be closely appressed, in which latter case they are often quite rudimentary; in some forms they assume the shape of hooks, especially the lower ones. In other (deep-sea) forms they partly assume a very elaborate,

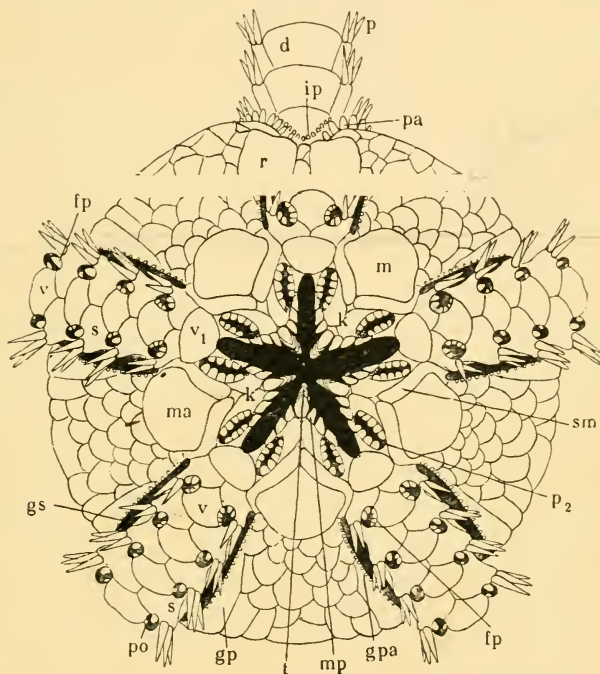


FIG. 84.—A Brittle-star (*Ophiura robusta*) from the oral side; at the upper edge of the figure part of dorsal side of disk and arm of another species (*Ophiura affinis*); enlarged. (From *Danmark's Fauna*.)

d, Dorsal plate; fp, Foot papillae or tentacle scales; gp, Genital plate; gpa, Genital papillae; gs, Genital or bursal slit; ip, Inner comb of papillae; k, Jaw; m, Mouth shield; ma, Madreporite; mp, Mouth papillae; p, Arm spines; pa, Outer comb of papillae; po, Pore of tube-foot; p₂, Second foot pore; r, Radial shield; s, Side or lateral plate; sm, Adoral shield; t, Teeth; v, Ventral plate; v₁, First ventral plate.

umbrella-like shape; but they are never transformed into pedicellariæ (as has been erroneously maintained), these organs being entirely unknown in the Ophiuroids.

In the corners between the ventral and the lateral plates are situated the pores through which the tube-feet or "tentacles" issue, one pair corresponding to each arm joint. On the edge of the pores some small papillae, the *tentacle scales*, are often found.

The tube-feet always lack a sucking disk, but may be covered with sensory papillæ; they play only an unimportant rôle, or none at all, as locomotory organs. The first pair of tube-feet are always situated in the depth of the mouth, near the point of the "jaws", viz. the five projecting mouth parts; the second pair is situated either near the edge, but still within the mouth, or wholly outside the mouth edge (as in *Ophiura*, Fig. 84). At the end of the arm there is an unpaired, terminal feeler, which can protrude through the tube-shaped terminal plate. No eye-spot is found on the terminal feeler.

The *mouth*, which is on the under-side, is star-shaped (Fig. 84); along the edges of the five projecting parts, the *jaws*, are usually found some papillæ, the *mouth-papillæ*; on the inner point of the jaw there are some other papillæ, either arranged in a single vertical series, or in several more or less regular series; when arranged in a single series they are designated as *teeth*, when in several series *tooth-papillæ* (e.g. *Ophiothrix*, Fig. 98). Not rarely, however, irregularities occur in species with normally a single series of teeth, so that something resembling tooth-papillæ results; this may occur especially in larger specimens. The tooth papillæ occupy only the outer part of the jaw; deeper within the mouth they continue in a series of teeth, which may have a strong cap of enamel. Outside the mouth papillæ there is on each side an elongated plate, the adoral plate, and in the angle between these a somewhat larger plate, the *mouth shield*, the shape of which is of great importance in classification. One of the mouth shields generally is slightly irregular and has one or a few pores near the edge. This is the madreporite. In many cases it is, however, very difficult to recognise as such, the pore being hidden under the edge of the plate.

Along the inner part of the arms are found in the interradii on the ventral side a pair of narrow slits, each leading into a large, thin-walled sac, the *bursa* (Fig. 85), which has a respiratory function. This *bursal* or *genital slit* as a rule extends from the mouth shield to the edge of the disk; often it carries a series of small papillæ, the *genital papillæ*, along its interradiial edge. A pair of larger, elongated plates, the *genital plates*, are situated along the edges of the slit, connected by a joint at the outer end of the slit; from here they extend farther out to the edge of the disk, where they articulate with the inside of the radial shields. The genital plates are, however, often indistinct. A few Ophiuroids lack bursæ and bursal slits completely. Some, mainly tropical, forms (*Ophioderma*) have two slits along each side of the arm;

in a single genus (*Ophioschiza*) there is only one slit in each interradius.

In the bottom of the star-shaped mouth is a simple, round opening that leads directly into the large, sac-shaped stomach, which fills up the whole disc. There is no intestine and no anal opening, the indigestible particles being expelled through the mouth. No hepatic cæca. No part of the intestinal organs passes into the arms. In the inner corner of each interradius a small, stalked vesicle, the *Polian vesicle*, is found beneath the stomach. The radial water-vessels are enclosed by the vertebræ. No ampullæ to the tube-feet. The radial nerve system well developed, not in the epidermis, as in the sea-stars, but in a furrow on the ventral side of the vertebræ, covered by the ventral plates. *Genital organs* or gonads situated at the base of the bursæ; in some *Asteroschematids* they lie partly in the base of the arms; they are mostly small, pear-shaped bodies, serially arranged (Fig. 85, 2), but in some forms they have the shape of a larger, leaf-shaped body. The sexual products are emptied into the bursæ, from which they pass out through the bursal slits. In the rare cases where bursæ are wanting, the sexual products are emptied through an opening formed in the body-wall for that purpose. A few species are

hermaphrodites and at the same time viviparous; this is the case with four of the British species, viz. *Amphipholis squamata*, *Amphiura borealis*, *Ophiomitrella clavigera*, and *Ophiacantha anomala*.

The brittle-stars are generally rather lively animals, which walk in a very peculiar way by means of the arms, these being thrown forwards in pairs and then pushing the animal forwards in jerks, almost as in leaps (Fig. 86). One of the arms, any one of them, is directed in front or backwards and does not actively assist in the walking. This way of moving is specially characteristic of species living on a hard bottom (*Ophiura*, etc.).

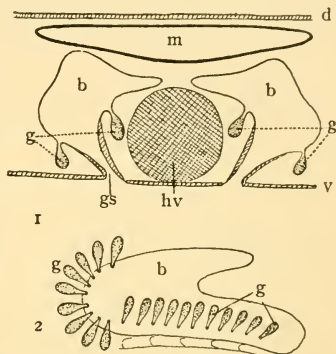


FIG. 85.—1. Diagrammatic transverse section of the proximal part of an arm, inside the edge of the disk, showing the situation of the bursæ and the genital organs. 2. Diagrammatic figure of a bursa with the genital organs attached to its wall (after Ludwig). (From *Danmark's Fauna*.)

b, Bursa; d, Dorsal body-wall; g, Genital organ (gonad); gs, Genital or bursal slit; hv, Arm vertebra; m, Stomach; v, Ventral body-wall.

Some species, especially *Ophiocomina nigra*, but also e.g. *Ophiura robusta* and *Amphipholis squamata*, are able to climb (e.g. the walls of the aquaria) by means of their tube-feet. Several Ophiuroids are phosphorescent, e.g. *Amphiura filiformis*, *Amphipholis squamata*, *Ophiopsila annulosa* and *aranaea*, *Ophiacantha bidentata*. The cells that secrete the luminous substance are situated at the base of the arm spines; the light, therefore, appears as a double series of luminous spots along each arm. As a rule the light is emitted only on irritating the animal.

The food of the brittle-stars consists of all sorts of small animals, especially molluscs and worms, which are carried to the mouth by means of the arms. The Euryalids appear to feed

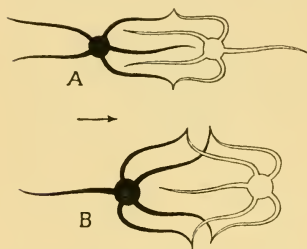


FIG. 86.—Diagrams showing the walking of a Brittle-star: in A, with the unpaired arm directed forwards; in B, directed backwards. The figure in outline shows the place of the Brittle-star after the leap. (After Ostergren; from *Danmark's Fauna*.)

exclusively on pelagic animals (Copepods, Appendicularians, etc.), which they catch by means of their arms. Several forms, mainly among the Amphiurids, dig themselves deep into the sand or mud, with only the ends of the arms above the ground.

On account of their exceedingly great numbers the brittle-stars play a rather important rôle in the economy of the sea, partly as food for fishes and other animals, partly as competitors for the available food, especially by devouring enormous numbers of young mussels. Some species are of primary importance as characterising animal

communities, as *Amphiura filiformis*, *Amphilepis*, *Ophiura affinis*.

The rate of growth has been examined for *Ophiura texturata*; it takes two years to reach sexual maturity, but three, or probably more years to reach full size. More recently Grieg has shown that *Ophiomusium lymani* takes about three years to reach full size, and he thinks the same to hold good for most other deep-sea Ophiuroids of the North Atlantic. All brittle-stars have a strong *regenerating power*. Not only are the arms easily regenerated, when lost, but also parts of the disk and the inner organs. Some Amphiurids, especially such as have the ventral side of the disk naked, without scales, are apt to throw off, when in any way hurt, the whole disk with the stomach, the bursæ, and the genital organs, afterwards regenerating all of it. Most brittle-stars are

able to throw off their arms when hurt or when anything merely takes hold of them. Some species propagate by *self-division*, the disk being divided across the middle; each half then regenerates the lacking part of the disk and the lacking arms, two new individuals being thus formed. This way of propagating is especially common in the genus *Ophiactis*, e.g. the Mediterranean *Ophiactis virens* and the North Atlantic *O. nidarosiensis*.

Parasites are not numerous in Ophiuroids. Some Infusoria may be found in the stomach of *Ophiura Sarsi* (and probably other species); in the genital organs of *Amphipholis squamata* the remarkable parasite *Rhopalura* is found, a primitive worm of the group of Mesozoa, peculiar through the entoderm consisting of only one or a few cells. A remarkable, but hitherto undescribed, parasitic organism is found in the gonads of *Ophiura Sarsi*, possibly a very much reduced Planarian. Parasitic snails have been found on a few Ophiuroids (e.g. *Ophiactis abyssicola*), but are on the whole rare. In *Gorgonocephalus caput-medusæ* (and other species) a very interesting parasite, *Protomyzostoma*, a relative of the *Myzostoma* infesting Crinoids, lives in the body cavity; it is a centimeter-long flat, red sac, filled up by an immense number of small eggs, and was, in fact, at first described as the genital organs of the *Gorgonocephalus*. Also the true *Myzostoma* has been recorded in a few cases from Ophiuroids (*Ophiacantha vivipara*, *Astroceras pergamena*, *Ophiocreas*). In *Ophiura albida* lives a Trematode, *Fellodistomum fellis* (Olsson), the sexual stage of which is found in the gall-bladder of *Anarrhichas*, which must therefore be infected through eating the Ophiuroid. Also a few Cercarias and young Nematods have been found in Ophiuroids. A few Crustaceans are found parasitic in Ophiuroids, viz. the very much transformed *Philichthys amphiuuræ* Hérouard, in the bursæ of *Amphipholis squamata*, a somewhat less transformed species, *Chordeumium obesum* (Jungersen), in the gonads of *Asteronyx loveni*; further, a related form which produces galls in the epidermis of a tropical Ophiuroid. Also in *Ophiomitrella clavigera* an (undescribed) parasitic Crustacean occurs, which even completely castrates its host. A semiparasitic Copepod, *Cancerilla tubulata* Dalyell, occurs on *Amphipholis squamata*. Finally is to be mentioned a curious instance of a parasitic Green-Alga, *Coccomyxa ophiuræ* Rosenvinge, occurring very commonly on *Ophiura texturata* and *albida* in the Limfjord (Denmark), and also observed on the coast of Bohuslén, Sweden, but not known elsewhere. It lives in the skin of the animal, dissolving the calcareous plates, and may even

dissolve the vertebræ so that the arms break ; where present in great quantity it no doubt causes the death of the animal.

Fossil Ophiuroids are on the whole rare and, excepting the Palæozoic forms, not of great importance, either from a morphological or from a geological point of view.

In the viviparous Ophiuroids (see above, p. 149) development takes place within the bursæ, and the young ones remain there until they have reached such a considerable size that it is almost

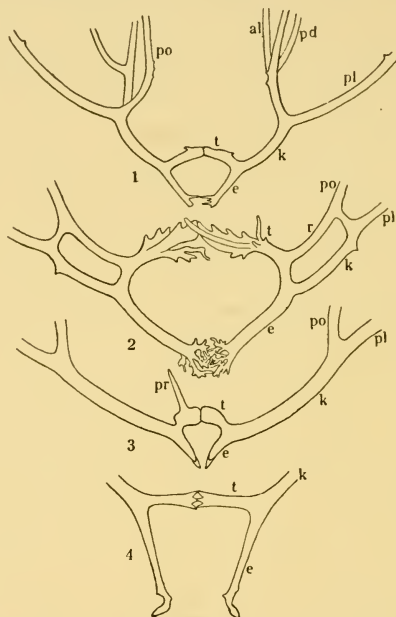


FIG. 87.—Skeleton of various Ophiuroid larvæ (*Ophiopluteus*).
(From *Danmark's Fauna*.)

1. *Ophiocomina nigra* ($\times 145$). 2. *Ophiopluteus ramosus* ($\times 100$). 3. *Ophiothrix fragilis* ($\times 100$). 4. *Ophiopluteus dubius*, posterior part of skeleton only ($\times 100$). al, Antero-lateral rod ; e, End rod ; k, Body rod ; pd, Postero-dorsal rod ; pl, Postero-lateral rod ; po, Postoral rod ; pr, Median rod ; r, Recurrent rod ; t, Transverse rod. In 2 the recurrent rod of only the one (ventral) side is drawn ; a corresponding one is found on the other (dorsal) side, the body skeleton thus forming two large, rectangular meshes in each side of the body.

inconceivable how they can get out through the narrow genital slits. Most Ophiuroids, however, have free-swimming, pelagic larvæ, *Ophiopluteus*, of a very characteristic shape, with long processes or "arms", among which the posterior lateral arms are the longest, and directed more or less obliquely forwards. They have a well-developed skeleton, consisting of two symmetric halves, joining in the posterior part of the animal (Fig. 3, 3 and Fig. 87). From the body-rod, which is either simple or compound, forming two meshes in each side of the body, proceed rods that

support the various arms and are named thereafter (Fig. 87); the body-rod continues backwards as the end rod, which is, as a rule, tripartite at the end. Some distance from the end proceed a pair of transverse rods, directed inwards and joining those from the opposite side, thus forming a ring beneath the stomach. The transverse rods may have a shorter or longer process, the median rod. The body skeleton is of special importance for distinguishing the various larval species. The arms of the larvæ may be narrow or broad, of various length, often very long. The larval body may have peculiar widenings, ciliated lobes. Often the posterior end carries a tuft of cilia, sometimes a ciliated ring. Generally the tip of the arms, especially the postero-lateral arms, is strongly pigmented. As a rule the stomach is greenish. Some Ophiuroid larvæ are more or less rudimentary, with feebly developed arms and indistinct ciliated band. During the metamorphosis the larval body, with the skeleton, is absorbed, either completely, or the postero-lateral arms remain unaltered and serve as floating apparatus for the young brittle-star, until the latter is ready to assume life on the bottom, when these arms are thrown off; they still remain in connection and may continue swimming for a little while, and are not rarely met with in plankton samples; but, of course, they soon perish. In a tropical form it appears that a new larval body may regenerate from these postero-lateral arms which have been thrown off. The young Ophiuroids may keep floating for some time, the long-extended tube-feet serving as a floating apparatus. The larval stage as a rule has a duration of a few weeks. The larvæ feed on minute pelagic organisms. Some Ophiuroids have direct development, without a pelagic larval stage; this probably holds good of those which have large, yolky eggs.

Key to the larvæ of Ophiuroids (Ophiopluteus) known from or likely to occur in the British seas. (Fig. 88.)

- | | |
|--|--------------------------------------|
| 1. Fully formed larva, with arms well developed and ciliated band distinct | 2 |
| Larva more or less rudimentary, ciliated band indistinct | 12 |
| 2. A ciliated ring around the posterior end of the body (skeleton unknown) | <i>Ophiopluteus coronatus</i> Mrtsn. |
| No ciliated ring around the posterior end of the body | 3 |
| 3. Body rod simple | 4 |
| Body rod forms two meshes | 11 |
| 4. Postero-dorsal arm lacking | 5 |
| Postero-dorsal arm present | 6 |

11. Transverse rods large, branched, serrate (Fig. 87, 2)

Ophiopluteus ramosus Mrtsn.

Transverse rods very short, only with a pair of small branches at the end (Fig. 113) *Ophiactis Balli*

12. Postero-lateral arms well developed; body-skeleton fairly complete (Fig. 133) *Ophiura affinis* (?)

Postero-lateral arms not developed; skeleton quite rudimentary (Fig. 89) *Ophiopluteus Claparèdei* Mrtsn.

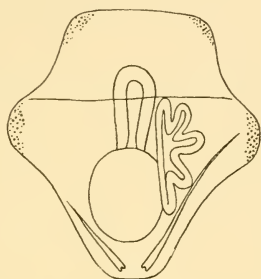


FIG. 89.—*Ophiopluteus Claparèdei*. Enlarged. (After Claparède; from Th. Mortensen, *Developm. and larval forms of Echinod.*)

Besides the larval forms enumerated in this key there is a possibility that *Ophiopluteus bimaculatus* (Joh. Müller) may also occur in the British seas, this Mediterranean larva having been found also off the Moroccan coast, down to the Cape Verde Islands. It belongs to the group of larvæ with composite body skeleton, but is distinguished from *Ophiopluteus ramosus* in having simple transverse rods and from the *Ophiactis Balli* larva in having a process from the transverse rods (median rod); it is further characterised by having a pair of black spots in the basal part of the body. It is unknown to which Ophiuroid this larva belongs.

Regarding the *Ophiopluteus* species named above, there is some reason for supposing that *Ophiopluteus dubius* may perhaps belong to *Amphiura Chiajei*, *Ophiopluteus compressus* to *Ophiura Sarsi*, whereas no suggestion can be given at present as to which Ophiuroids the larvæ *Ophiopluteus coronatus*, *ramosus*, and *Claparèdei* belong.

The classification of the brittle-stars is not yet definitely settled. A much-used classification is that of Bell, dividing them according to the type of vertebral articulation into *Astrophiuuræ* or *Cladophiuuræ*, with hour-glass-shaped articular surfaces, the *Streptophiuuræ*, with a simple ball-and-socket joint as vertebral

articulation, and the *Zygophiuræ*, in which the articulating surface bears various processes and pits. It has the great fault that the difference between the *Streptophiuræ* and *Zygophiuræ* is not real—in fact, the vertebræ of the “*Streptophiuræ*” are of the same type as those of the “*Zygophiuræ*,” whereas the difference in regard to the vertebral articulation between the *Zygophiuræ* and the *Cladophiuræ* appears to be real enough and to mark two main groups of the brittle-stars. Another, more recent classification, proposed by Matsumoto, is mainly founded on differences in the shape of the first vertebræ and the articulation of the genital plate with the radial shield; it divides the Ophiurans into the following orders: *Phrynophiuræ*, *Læmophiuræ*, *Gnathophiuræ*, and *Chilophiuræ*.

The present author cannot accept this classification; especially the *Phrynophiuridæ* seem a very artificial group, containing both the *Ophiomyxidæ* and the *Euryalids*. The *Ophiomyxidæ* may well be regarded as the most primitive of *Zygophiurids*, but they are probably not nearly related to the *Euryalids*, with quite a different type of vertebræ. The more natural classification, therefore, would be the old one, dividing the Ophiuroids into the two orders: *Ophiuræ* (= *Zygophiuræ*) and *Euryalæ* (= *Cladophiuræ*). Which of these groups is the more primitive is hard to say in our present state of knowledge. If the *Euryalids* are placed first here, this does not mean to say definitely that the author would regard them as the less specialised type.

Key to the Orders of Ophiuroids.

- The arms are moved vertically; articulation of vertebræ by means of hourglass-shaped surfaces. No distinct scale-covering, but disk and arms covered by a thick soft skin or a mosaic of granules. Spines downwardly directed. Arms simple or branched I. *Euryalæ*
- The arms are as a rule moved horizontally; articulation of vertebræ by means of various pits and processes. Mostly a distinct scale-covering on disk and arms, more rarely a soft skin covers the scales. Arm spines not downwardly directed; arms simple II. *Ophiuræ*

I. Order. EURYALÆ Müller and Troschel.

(Syn. *Astrophium*, *Cladophium* Bell.)

Disk and arms covered by naked skin or by a close coat of granules, more rarely with distinct scales. Ventral and dorsal plates of arms lacking or more or less rudimentary, covered by

the thick skin. Side arm plates small, occupying only the lower side edge of the arms. Spines downwardly directed (or at least partly so), often transformed into hooks or thick, spiny clubs. The arms, which may be simple or branched, are moved mainly in a vertical direction, rolling in or up, or winding themselves round corals or the like, the hourglass-shaped articular surfaces of the vertebræ making such movements possible. Genital slits mostly short, broad, often placed vertically on the edge of the disk at the base of the arms. There may be one madreporite in each interradius.

Two families of this order are represented in British seas, but one more, the family *Asteroschematidæ* may be expected to be represented there also, two genera of that family being known from the North-east Atlantic, viz. *Asteroschema* Örsted and Lütken (one species, *A. inornatum* Koehler, found in the Bay of Biscay and off Madeira, 1480 m.), and *Ophiocreas* Lyman (one species, *O. oedipus* Lyman, found off Madeira, 1500-1968 m.). This family therefore is included in the key. The two genera are very easily distinguished through one, *Asteroschema*, being covered all over with fine grains, the other, *Ophiocreas*, by a thick, soft skin. The families *Astronychidæ* and *Asteroschematidæ* are by some authors regarded only as subfamilies of the family *Trichasteridæ*, or even simply included in the latter family.

Key to the families of Euryalæ known from or expected to be represented in the British seas.

1. Arms branched; arms covered with grains and bearing rings of hooks at least on the outer part . . . II. *Gorgonocephalidæ*
 Arms unbranched. Arms without rings of hooks . . . 2
2. Disk large, or fairly large; arms slender, distinctly defined against the disk; three or more arm spines; only one madreporite . . . I. *Asteronychidæ*
 Disk very small, arms very stout, often very indistinctly defined against the disk; only two unequal arm spines; one madreporite to each interradius¹ . . . *Asteroschematidæ*

I. Family ASTERONYCHIDÆ

Disk fairly large, well marked off from the long and slender unbranched arms, which are covered by a thick skin. Disk covered with skin or rather distinctly scaled. Genital slits small, just outside the mouth shields, not vertical. Mouth papillæ fairly

¹ The madreporites are generally not to be seen without special preparation.

well developed. Three or more arm spines. Only one madreporite.

One genus, *Asteronyx*, known from the British seas, but another, *Astrodia* Verrill, may be expected to occur there also, the species *Astrodia tenuispina* Verrill having been found off Spain and Portugal ($42^{\circ} 1' - 38^{\circ} 5' \text{ N.}$, ca. 12° W. , 2365-3307 m. "Talisman"). The characters of this genus are therefore given in the key.

Key to the genera of Asteronychidæ known from or likely to occur in the British seas.

Disk and arms covered with skin, through which only the large radial shields are seen. Arm spines (in the European species) up to 8-9. Mouth papillæ narrow, spiniform

1. *Asteronyx* Müller and Troschel

Disk and base of arms with fairly distinct, not imbricating, scales. Three arm spines. Mouth papillæ broad, scale-like

Astrodia Verrill

1. *Asteronyx* Müller and Troschel.

Disk naked, covered with a rather thick skin, through which the large radial shields are more or less plainly visible. Lateral plates small, forming a more or less projecting edge along the lower side of the arms. Spines three or more, the lower one the largest, mostly strongly club-shaped, the others shorter, more or less hook-shaped. Mouth papillæ small, papilliform, not broad, scale-like.

Only one species in European seas.

1. *Asteronyx Loveni* Müller and Troschel. (Fig. 90.)
(Syn. *Asteronyx Locardi* Koehler.)

Radial shields in the shape of narrow ribs, which reach almost to the middle of the disk. On dried specimens the skin is seen to contain some few scattered, small plates. Dorsal plates are lacking, the ventral plates are rather well developed, but irregular (distinct only after removing the skin, by means of potash or hypochlorite of sodium). The arms are usually conspicuously unequal, two or three of them being generally much longer and thicker than the others. On these longer arms the lowermost spine is, mainly in the middle of the arm, long and club-shaped, thorny, and clad in a thick skin; mostly it is directed obliquely towards the ventral side of the arm. The other arm spines, generally 8-9 in number, are short, hook-shaped. On the thinner

arms all the spines are short, hook-shaped ; this also holds good of the younger specimens, where all the arms are still equal in size. No spines at the first pair of pores ; no tentacle scales. Mouth shields very small or even lacking in larger specimens ; only the madreporite fairly well developed. Colour a faint reddish. Reaches a very considerable size, up to ca. 35 mm. diameter of disk. The stronger arms up to ten times as long as diameter of disk.

Development unknown ; from the rather large size of the eggs it is, however, fairly evident that the development must be direct, without a pelagic larval stage. In very young specimens the disk is covered by large primary plates, forming a beautiful rosette ; these plates, however, gradually disappear, being totally dissolved. In specimens of a size of ca. 2 mm. diameter of disk and an arm length of ca. 10-15 mm. the terminal plate is large, basket-shaped ; it then gradually assumes a simple, cylindrical shape.

It is generally found clinging high above the ground to slender Pennatulids, like *Funiculina quadrangularis*, more rarely to Gorgonids. It has two or three of the arms wound around the Pennatulid, the other arms waving free in the water, catching the small pelagic animals (mainly Copepods) on which it feeds. It appears

that it also to some degree feeds on the polyps of the Pennatulid to which it clings. The young specimens are detritus-eaters, until at a size of ca. 5-6 mm. diameter of disk they crawl up and attach themselves to the Pennatulid, then becoming plankton-eaters.

The remarkable transformed Copepod, *Chordeumium obesum* (Jungersen), is rather commonly found parasitic in its gonads, which are destroyed by the parasite ; the other gonads, however, go on functioning normally, the Ophiuroid thus not being castrated by the parasite.

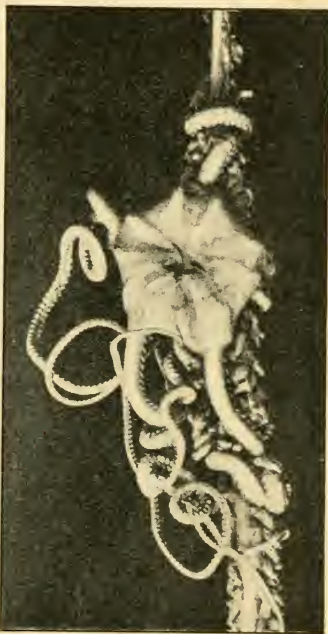


FIG. 90.—*Asteronyx Loveni*, clinging to a *Funiculina*. Seen from the dorsal side. Nat. size. (From *Danmark's Fauna*.)

In British seas this species appears to be rather rare, having been found only off Aberdeen, Moray Firth, the Minch, Loch Torridon, Loch Hourn, and Firth of Lorn; more recently it has been recorded from off S.W. Ireland ("Mich. Sars"). Otherwise it has an almost cosmopolitan distribution, being known from the Scandinavian seas to Finmark in the north, from the American coast down to the West Indies; farther from Cape, the Indian Ocean, and the Pacific from Australia to the Bering Sea. The bathymetrical distribution is ca. 100-ca. 1800 m.¹

II. Family GORGONOCEPHALIDÆ

Disk large, covered with grains, spines, or a naked skin. Arms simple or branching, covered with grains and, at least on the finer branches, bearing rings of fine, microscopical hooks. Mouth papillæ spiniform. Arm spines (or tentacle scales) small. One or five madreporites. A bundle of short cæca proceed from the water vascular ring in each radius.²

Only one genus represented in British seas. Another genus, *Astrospartus* Döderlein, with the species *A. mediterraneus* (Risso), occurs in the Mediterranean and along the Moroccan coast, at least down to Cape Blanc. It is not known farther north, and as it is a littoral form, there is scarcely any prospect of finding it in the British seas. (It is easily distinguished by the tentacle scales lacking on the inner part of the arm, unto the first division.)

1. *Gorgonocephalus* Leach.

Arms branched from the base; arm spines (or tentacle scales) beginning at the second pair of tube-feet. Only one madreporite. A series of plates along edge of disk in the interradial spaces. Genital organs small, very numerous, in several series on the bursæ, which latter are all in mutual connection.

The species of this genus live rather gregariously; on rocky ground, swept by currents, they may be found in great numbers, covering the ground, clinging to one another, their richly branching arms forming a dense network in which are caught the pelagic organisms (Copepods, Appendicularians, etc.) on which they

¹ The statement that it was found in a depth of only 9 fathoms in Loch Torridon (Stewart) is probably due to some mistake; it has otherwise never been recorded from so small a depth.

² Possibly corresponding to the "Tiedemann's bodies" in Asteroids, which are also organs attached to the watervascular ring. Till now known only in this genus, but will probably be found to be a family character.

feed. They are also often found clinging to Gorgonians. They reach a considerable size, up to ca. 10 cm. diameter of disk.

The development is only partially known. The eggs (at least of *G. caput-medusæ*) are laid free in the water, but it is unknown whether they develop into an Ophiopluteus larva. It appears that the young, newly metamorphosed Gorgonocephalus (at least *G. eucnemis*) lives parasitic on the polyps of the Alcyonarian *Eunephthya* (*Gersemia*). At the stage when branching of the arms begins they leave the Alcyonarian and may then seek the adult specimens, on the backs of which the further growth stages are often found.

The remarkable parasite *Protomyzostomum* (related to the *Myzostoma* of Crinoids) lives in the body cavity of *Gorgonocephalus*. It enters the gonads, the content of which is destroyed, their walls forming a cyst around the parasite (cf. p. 151). It does not castrate its host, the gonads not directly destroyed by the parasite functioning normally.

Preserving Gorgonocephalus with the arms well expanded requires a special treatment. Some species are best killed in formalin, others, e.g. *G. caput-medusæ*, may be very beautifully preserved by putting the well-expanded specimens into fresh water by which they become completely paralysed, and then transferring them into formalin or alcohol.

Three species are known from the British seas. A fourth species, *Gorgonoc. arcticus* (Leach) (Syn. *G. Agassizi* Stimpson), occurs in the Arctic seas and at least as far south in the Norwegian sea as 62° 43' N., 1° 26' S. ("Michael Sars"); it may well be expected to occur also as far south as the cold area proceeds in the Faroe Channel, and is therefore included in the key.

Key to the species of Gorgonocephalus known from or likely to occur in the British seas.

1. Disk wholly covered with coarse or fine spines; those on the radial ribs not specially prominent 2
- Disk naked, only the radial ribs with some larger spines or with smooth, rounded grains 3
2. Disk with rather coarse spines or tubercles; arm spines smooth, curved 1. *Gorg. caput-medusæ* (Linn.)
- Disk closely covered with fine spinelets; arm spines compressed, coarsely pectinate (Fig. 93, 1)
3. *Gorg. Lamarcki* (Müll. and Trosch.)
3. Radial ribs with rounded grains
2. *Gorg. eucnemis* (Müll. and Trosch.)
- Radial ribs with larger spines *Gorg. arcticus* (Leach)

1. *Gorgonocephalus caput-medusæ* (Linnæus). (Fig. 91.)

(Syn. *Gorgonocephalus Linckii* (Müll. and Troschel);
Astrophyton scutatum Forbes.)

Disk set with rather numerous short, coarse, conical spines; on the oral side in the interradial areas they are smaller, more

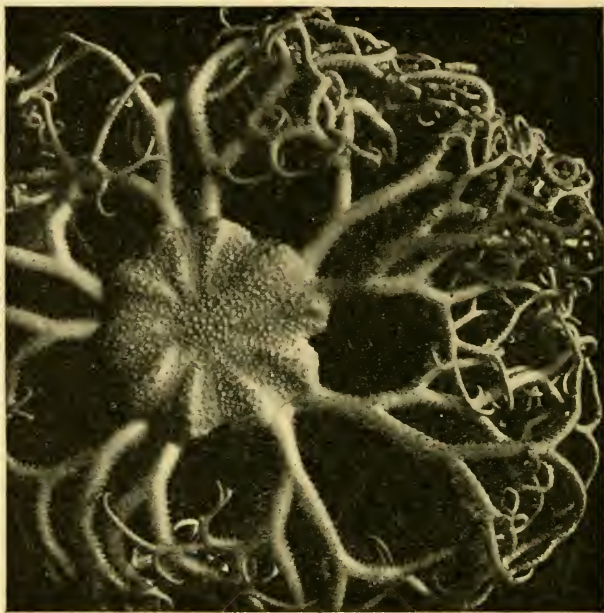


FIG. 91.—*Gorgonocephalus caput-medusæ*. Young specimen.
 Nat. size. (From *Danmark's Fauna*.)

like grains. Radial shields fairly prominent. Arms closely covered by fine grains. The belts of hooks distinct only after the third-fourth ramification; the hooks are ca. $\frac{1}{8}$ mm. long, glassy, with a small thorn below the point (Fig. 92). They are arranged in two series across the dorsal side of each arm-joint, bent backwards so as to turn their backs towards each other. Ventral side of arms covered with small grains to the mouth edge, concealing the ventral plates. Arm spines (or tentacle scales) short, smooth, curved. At the inner 2-3 pores there are



FIG. 92.—Hook from arm of *Gorgonocephalus caput-medusæ*. $\times 100$.
 (From *Danmark's Fauna*.)

two of them, then three, and from about the first ramification four; on the outer branches they are somewhat hook-shaped. Colour reddish or yellowish, sometimes almost white. Reaches a size of ca. 9 cm. diameter of disk.

In British seas this species is known from Cornwall, Shetland, the Orkneys, and Firth of Forth; more recently it has been recorded from the Lousy Bank and off S.W. Ireland ($51^{\circ} 37' \text{ N.}$, $11^{\circ} 56' \text{ W.}$, 610-664 fms., "Helga"). It is elsewhere known only from the Scandinavian seas, from Skagerrack to the Trondhjem Fjord, from depths of ca. 150-1200 m.

2. *Gorgonocephalus eucnemis* (Müller and Troschel). (Fig. 93, 2.)

(Syn. *Astrophyton Malmgreni* Danielssen and Koren.)

Disk as a rule naked above and below, only the rather prominent rib-like radial shields covered with a coat of small, round granules. Ventral side of arms wholly naked, covered only with a smooth skin, through which the ventral plates are fairly distinctly seen, in dried specimens. Spines, or tentacle scales, simple, smooth (Fig. 93, 2), 2-4 as in *G. caput-medusæ*. Colour in life brownish, radial shields somewhat lighter. Reaches about the same size as *G. caput-medusæ*, or even somewhat more.

From the British seas this species is known from the cold area of the Faroe Channel ("Porcupine", "Michael Sars"); it has also been recorded from the warm area of the Faroe Channel ("Triton"); this, however, is due to a misidentification of the following species.¹

Gorg. eucnemis is widely distributed in the Arctic seas, to Spitzbergen, the Kara Sea, and the Siberian Sea. It further occurs in the Greenland seas, down to Cape Cod on the American coast. Very probably the North Pacific *Gorg. caryi* Lyman is the same species as *eucnemis*, which will then be circumpolar. Its bathymetrical distribution is ca. 15-1850 m.

¹ It has also been recorded from the Lousy Bank, but most probably this is likewise due to confusion with *G. Lamarcki*.

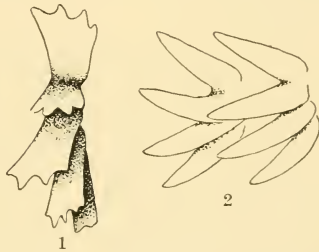


FIG. 93.—Arm spines (or tentacle scales) of *Gorgonocephalus Lamarcki* (1) and *G. eucnemis* (2). 1. $\times 22$; 2. $\times 9$.

3. *Gorgonocephalus Lamarcki* (Müll. and Troschel). (Fig. 93, 1.)

Disk closely set with small, fine spinelets giving it a smooth, almost velvety, appearance; these spinelets continue some distance out on the arms. Underside of arms more or less granulated, the ventral plates not showing through the skin in dried specimens. Five arm spines, which are rather coarsely dentate (Fig. 93, 1). Colour in life yellowish-brown. Reaches about the same size as *G. caput-medusæ*.

In British seas this species has been found in the warm area of the Faroe Channel (60° 11' N., 8° 15' W., 780 m., "Triton"; recorded under the erroneous name *G. eucnemis*); also the "Michael Sars" has found it here in several places. Probably the *G. eucnemis* from the Lousy Bank also is *G. Lamarcki*. It is otherwise known from Finmark to Bergen, Iceland, Greenland, and N. America down to Nova Scotia. Bathymetrical distribution ca. 75-780 m.

II. Order. OPHIURÆ Müller and Troschel.

(Syn. *Streptophiuræ* and *Zygophiuræ* Bell.)

Disk and arms with distinct scales, which may, however, be concealed by grains or spines or by a naked skin. Side arm plates large, not confined to lower edge of arms, often joining in the dorsal and ventral mid-line. Spines not directed downwards, more rarely partly transformed into hooks. The arms, which are always simple, unbranched, are moved mainly in the horizontal direction, the articulation of the vertebræ by means of various pits and processes ("zygospondylous" articulation), mainly allowing a horizontal movement. Genital slits never vertical, as a rule long and narrow, extending from mouth shield to edge of disk; rarely each genital slit is divided into an inner and outer part, being coalesced in the middle. Only one madreporite present.

This order contains the great bulk of the Ophiurans. The very numerous forms are divided into a number of families, of which nine are known to be represented in British seas. Besides these, two more may be expected likewise to be represented there, viz. the *Ophioleucidæ* and the *Ophiidermatidæ*, which would mean that practically all the known families of the order Ophiuræ, excepting only the Hemieuryalidæ, would be represented in the British seas. The family Ophioleucidæ, which is represented in European seas by two genera, is specially mentioned on p. 227; the family

Ophiidermatidæ, represented in the European seas by four genera, is mentioned on p. 225.

Key to the families of Ophiuræ known from or likely to be represented in the British seas.

1. Disk and arms covered with a thick, naked skin,¹ concealing the scales of the disk and the arm plates ; arm spines erect

I. *Ophiomyxidæ*

Disk and arms not covered with a thick skin 2

2. Arm spines appressed, often rudimentary 3

Arm spines erect (or outstanding) 5

3. Disk on both sides closely covered by granules, which conceal the scales *Ophiidermatidæ*

Disk not, or only partly, covered with grains 4

4. Disk partly with granules, which leave, at least, the large, rounded radial shields naked. Arms long and slender, flexible, fragile. Pores usually large, or wholly covered by one large tentacle scale *Ophiroleucidæ*

Disk scales distinct, not covered by granules, rarely (the genus *Ophiopleura*) concealed by skin IX. *Ophiolepidæ*

5. Tooth papillæ present 6

No tooth papillæ, only a single vertical series of teeth 7

6. Mouth papillæ present III. *Ophiocomidæ*

No mouth papillæ II. *Ophiotrichidæ*

7. An unpaired (infradental) papilla on apex of jaw 8

A pair of (infradental) papillæ on apex of jaw

VI. *Amphiuridæ*

8. Second pair of tentacle pores outside the mouth edge ; small, delicate forms, with smooth disk and very long, thin and slender arms VII. *Amphilepidæ*

Second pair of tentacle pores inside the mouth edge ; disk often with spines or granules 9

9. Mouth papillæ form a continuous series with the infradental papilla 10

Mouth papillæ do not form a continuous series with the infradental papilla V. *Ophiactidæ* (partly)

¹ A fairly thick skin is found also in some other forms, e.g. *Ophiopleura*, *Ophiotoma*, and *Ophiolebes*. The first of these (of the family *Ophiolepidæ*) is at once distinguished from the *Ophiomyxidæ* by its rudimentary, appressed spines. *Ophiotoma* (of the family *Ophiacanthidæ*) has the arm plates distinct, not covered by thick skin ; *Ophiolebes*, likewise of the *Ophiacanthidæ*, is distinguished (*i.e.* the two N.E. Atlantic species) from the *Ophiomyxidæ* by the disk being closely set with rather coarse granules or globules. Also *Ophiopsila* (of the family *Ophiocomidæ*) may be mentioned here as having the disk apparently naked ; in reality it is not so, but covered with exceedingly fine scales, and the plates of arms are not concealed by skin ; this also holds good of *Amphiura securigera*, in which the disk is really naked, wholly without scales, but with long, narrow radial shields.

10. Disk large and flat, with naked scales ; arms stout, straight, with a distinct keel along ventral mid-line, often also along dorsal mid-line VIII. *Ophiochitonidae*
 Disk usually small, mostly with spines or granules ; arms not keeled, often moniliform, usually much curved 11
11. Disk with distinct, naked scales ; arms slender, not moniliform ; arm spines few, short, conical, equal-sized ; first ventral plate often divided (genus *Amphiactis*) V. *Ophiactidae* (partly)
 Disk usually with spines, stumps or granules, more or less completely covering the scales ; arm spines usually numerous, long and slender, of unequal length, the uppermost the longest IV. *Ophiacanthidae*

(As the distinguishing character used under section 2 of this key: spines appressed or erect, may not always be so distinct as to be indubitable (*e.g.* *Ophiochiton*, some *Ophiolepidæ*), it is advisable, especially for the beginner, to whom the general appearance of the various families is not yet familiar, to test the decision, whenever it seems doubtful, by comparison with the special descriptions and the figures. To make the key to the families of the Ophiuræ so complete as to exclude mistakes by the beginner would necessitate the use of anatomical characters observable only on dissection, which would not be desirable in a work like the present one.)

I. Family OPHIOMYXIDÆ

A thick, naked skin covers both disk and arms, concealing the scales and plates ; even when dried the plates are only indistinctly observable. Radial shields more or less rudimentary. Scales of disk mostly very fine, glassy, elliptical disks, with few small holes or none, observable only by microscopical examination of the skin. Dorsal plates of arms rudimentary ; ventral plates well developed. Mouth papillæ present ; teeth or tooth papillæ. Second pair of tube-feet outside or inside the mouth edge. Spines erect, covered with skin, but when dried or the skin removed, seen to be more or less glassy and thorny.

The skin of the disk is exceedingly brittle, and simply dissolves on specimens lying only a few minutes in the air before being preserved. Specimens in the collections therefore are very often in a poor state of preservation.

Development and biology of the European forms of this family unknown. Some littoral forms of the sub-antarctic regions are viviparous, but not hermaphrodites, in contradistinction to most other viviparous Ophiuroids.

Three genera are known from the British seas, but two more have been recorded from deep water off the Azores and might thus be expected to occur also in British seas. These are *Ophiogeron* Lyman, with the species *O. edentulus* Lyman (38° 11' N., 27° 9' W., 1620 m., "Challenger"), and *Astrogeron* Verrill, with the species *A. supinus* (Lyman) (38° 35' N., 28° 6' W., 1250 m., "Princesse Alice"). They are distinguished by the former having no mouth papillæ, except a single infradental papilla on apex of jaw, the second by having numerous small mouth papillæ and a cluster of small spines on apex of jaw. The fact that the two species were found at almost the same locality, however, leads to the suggestion that some mistake has taken place, and that the Atlantic specimen of *Ophiogeron edentulus* of the "Challenger" were really the same as *Astrogeron supinus* (the type of *O. edentulus* was taken off the Fiji Islands). In the key to the genera of this family, therefore, only *Astrogeron* is included.

Key to the genera of Ophiomyxidæ known from or likely to occur in British seas.

1. Mouth papillæ broad, scale-like, with serrate edge
 1. *Ophiomyxa* Müll. and Troschel
 Mouth papillæ slender, spine-like 2
2. A cluster of spines (tooth papillæ) on apex of jaw 3
 - A single (infradental) papilla on apex of jaw; ¹ radial shields rudimentary, without a comb of spines; arm spines three or more 2. *Ophioscolex* Müll. and Troschel
3. Radial shields fairly well developed, with a comb of spines
 3. *Ophiophrixus* H. L. Clark
 Radial shields quite rudimentary, without a comb of spines.
 Arm spines 2 *Astrogeron* Verrill

1. *Ophiomyxa* Müller and Troschel.

(Syn. *Ophiodera* Verrill.)

Skin of disk containing numerous very fine, glassy plates. Radial shields quite rudimentary. A more or less distinct series of scales along margin of disk. Mouth papillæ broad, scale-like, with coarsely serrate edges; teeth of the same shape. No tooth papillæ.

One species is known from the British seas. Another species,

¹ Large specimens of *Ophioscolex glacialis* may have more than a single infradental papilla, more like a cluster of spines or tooth papillæ. Such specimens are easily distinguished from *Ophiophrixus* by having no spines on the radial shields (which are quite indistinct), and from *Astrogeron* by having more than two arm spines.

Ophiomyxa pentagona Müll. and Troschel, is common in the Mediterranean and along the African coast down to Cape Verde ; but it has been found also at the north coast of Spain ("Talisman"), so there may be a possibility that it occurs also off the British south coasts. It is mainly a littoral form, but it is known from depths down to 235 m.

Key to the species of Ophiomyxa known from or likely to occur in the British seas.

Arm spines 5 or 4 (3) ; ventral plates with a deep notch in the outer edge, well separated (Fig. 94, b) *O. pentagona* Müll. and Troschel
 Arm spines 4 or 3 (2) ; ventral plates broadly in contact ; no notch in the outer edge (Fig. 94, a) . 1. *O. serpentaria* Lyman

1. *Ophiomyxa serpentaria* Lyman. (Fig. 94, a.)

(Syn. *Ophiodera serpentaria* (Lyman).)

Disk wholly naked. Marginal series of scales rather indistinct. Mouth papillæ three, more rarely four, generally increasing in

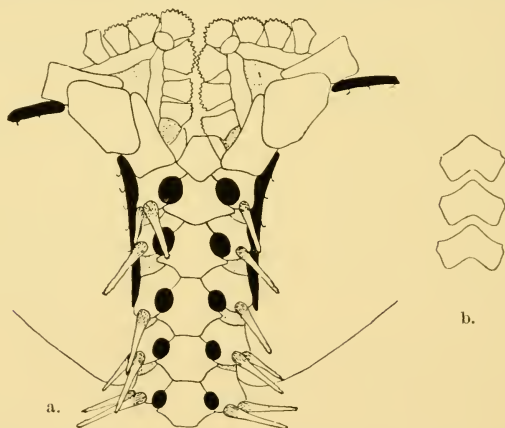


FIG. 94.—Part of oral side of *Ophiomyxa serpentaria* (a) and three ventral arm plates of *O. pentagona* (b). $\times 6$.

size inwards. Mouth shield broader than long, with a rounded peak inwards. Ventral plates produced laterally, broadly contiguous. Pores large, decreasing in size outwards, without tentacle scale. Genital slits reaching to about the fourth arm joint. Arm spines mostly three, but there may be four in some joints, only two in others, and as they are not placed in the same height on successive joints, even where the number is the same, there is a good deal of irregularity in the arrangement of the

spines. The upper one is, as a rule, somewhat coarser and longer than the others. Diameter of disk up to ca. 20 mm.; arms ca. four times the diameter of the disk. Colour in life unknown.

In British seas this species has been found in the Faroe Channel, 59° 56' N., 6° 27' W., 653 m. ("Porcupine"), and off S.W. Ireland, in 687-1224 m. ("Helga"). It has elsewhere been recorded from off the Azores and from Denmark Strait, and is thus evidently distributed over the whole of the N.E. Atlantic. Bathymetrical distribution ca. 600-1200 m.

2. *Ophioscolex* Müller and Troschel.

Disk naked or with scattered small spines; the skin contains numerous fine, glassy scales. No larger marginal scales. Radial shields indistinct or in the form of more or less distinct ridges. Mouth papillæ spine-like, as are also the teeth, which are arranged in a single series, only exceptionally, in large specimens, in a small cluster on apex of jaw.

Two species known from the British (and European) seas.¹

*Key to the species of Ophioscolex known from the British
(and European) seas.*

Disk entirely naked; no tentacle scales

1. *O. glacialis* Müll. and Troschel

Disk with small spines; one slender tentacle scale

2. *O. purpureus* Düb. and Kor.

1. *Ophioscolex glacialis* Müller and Troschel. (Fig. 95, b, e.)

Skin of disk quite naked. Dorsal plates of arms rudimentary, scarcely observable without a special microscopical examination; what is seen along the dorsal side of the arms in dried specimens is the dorsal side of the vertebræ. Ventral plates well developed, contiguous, with slightly convex distal edge. 3, exceptionally 4, slender arm spines, which are not transformed into hooks in distal part of arms. No tentacle scales. 3-6 slender mouth papillæ on each side, chiefly on inner part of jaw; in large specimens there may be a group of papillæ on apex of jaw. Mouth shield small, triangular; adoral shields each with a spine. Diameter of disk up to ca. 25 mm.; length of arms ca. five times the diameter of disk. Colour in life yellow, reddish or violet.

It is strongly phosphorescent on the arms. Lives on muddy bottom.

¹ The "*Ophioscolex relictus*" Koehler from the Bay of Biscay ("Caudan") is no *Ophioscolex* but an *Ophiolebes* (of the Ophiacanthidae).

In British seas this species has been found only in the cold area of the Faroe Channel ca. 500-1100 m. ("Porcupine", "Mich. Sars"). It is elsewhere distributed from Skagerrack to Spitzbergen, and from Greenland to 38° N. on the American coast. Bathymetrical distribution ca. 50-1900 m.

2. *Ophioscolex purpureus* Düben and Koren. (Fig. 95, *a*, *c*, and *d*.)

Disk with scattered, small spines (often distinct only on drying the specimens). Dorsal plates of arms rather well developed,

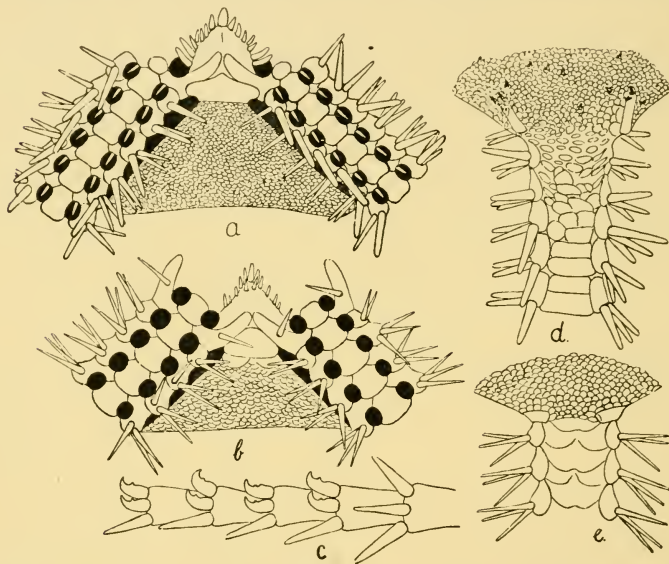


FIG. 95.—*Ophioscolex glacialis* (*b* and *e*) and *O. purpureus* (*a*, *c*, and *d*). $\times 6$. (After Th. Mortensen, *Scand. Echinod.*)

a and *b*, Part of oral side; *d* and *e*, Dorsal side of arm, proximal part, with adjoining part of disk; *c*, Part of arm of *O. purpureus*, near the end, in side view; shows the spines transformed into hooks.

covering the whole dorsal side of arms so that the vertebræ are not seen; proximally they are rather irregular, farther out more regular, two to each segment (Fig. 95, *d*). Ventral plates in the main as in *glacialis*. Mouth shields broad, low; adoral shields without spine. Arm spines 3, fairly thick, smooth; in the distal part of arm the two upper spines are transformed into hooks. One slender tentacle scale. Six to ten mouth papillæ on each side of jaw. Colour as in *glacialis*. Appears not to reach quite as large a size as that species.

Judging from an interesting observation by Grieg it would

appear that it breeds only once and then dies. Occurs on muddy bottom like *glacialis*.

In British seas this species has been found in the warm area of the Faroe Channel ("Porcupine"), and off S.W. Ireland ("Helga"), in 115-1380 m. A statement of its occurrence in the cold area of the Faroe Channel (Hoyle) may perhaps rest on a misidentification (*O. glacialis*?). The species is elsewhere known from Hardanger fjord on the coast of Norway to the White Sea, and from the Bay of Biscay ("Talisman"). Also known from Greenland, while the record of its occurrence in the West Indies rests on a misidentification. Bathymetrical distribution ca. 75-1380 m.

3. *Ophiophrixus* H. L. Clark.

Disk with scattered spines, attached to small plates in the skin, which does not contain any glassy scales. Radial shields fairly well developed, carrying a comb of spines. Tooth papillæ present.

One species known from the British (and European) seas.

1. *Ophiophrixus spinosus* (Storm). (Figs. 96, 97.)

(Syn. *Ophiobyrsa hystricis* (Lyman); *Ophioscolex spinosus* Storm; *Ophiobyrsella spinosa* (Storm).)

Dorsal plates of arms fairly well developed, divided by a longitudinal furrow. Ventral plates short and broad in the proximal part, farther out longer, contiguous, with a notch in the outer edge. No tentacle scale. Arm spines 4-5, rather long, closely set with small thorns (seen only after removal of the skin). Mouth shields about as long as broad, somewhat rhombic. Adoral shields broad, joining inside the mouth shield. Mouth papillæ and tooth papillæ rather long, spine-like. Reaches a size of nearly 30 mm. diameter of disk. Length of arms nearly ten times the diameter of disk. Colour in life brick-red; tube-feet yellow.

This species, which has hitherto erroneously been named *Ophiobyrsa hystricis*, is probably the largest of British Ophiuroids (not counting *Gorgonocephalus*). It has been found in the cold area of the Faroe Channel ("Porcupine") and on several places of S.W. Ireland ("Flying Fox", "Helga") in depths of ca. 400-1250 m.; also recorded from the Lousy Bank. It is elsewhere known only from the Trondhjemfjord and from between Madeira and the African coast ("Talisman"). The occurrence in the

cold area of the Faroe Channel is very remarkable, and needs verification.

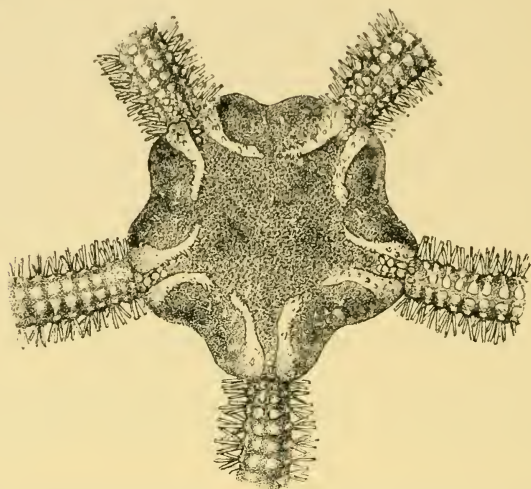


FIG. 96.—*Ophiophrixus spinosus* ; arms cut off near base. Nat. size.
(After Bell, *Classific. Ophiuroids.*)

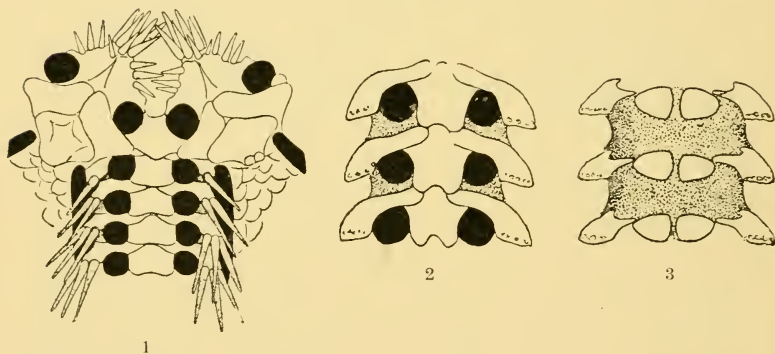


FIG. 97.—*Ophiophrixus spinosus*. Part of oral side (1), of ventral (2), and dorsal side of arm (3); skin removed so as to show the plates distinctly. 1. $\times 4$; 2-3. $\times 8$. (After Th. Mortensen, *Echinod. Trondhjem Fjord.*)

II. Family OPHIOTRICHIDÆ

Disk with well-developed scales, which may be more or less concealed by small spines or thorny stumps. Radial shields large. Both dorsal and ventral arm plates well developed. No mouth papillæ, but a group of tooth papillæ, and inside these a series of broad, strong teeth on apex of jaws. Second pair of tube-feet inside the mouth edge. Spines erect, generally distinctly thorny.

Only one genus, *Ophiothrix* Müll. and Troschel, known from the British seas, and from the North Atlantic and the Mediterranean. Only on the African coast two more genera are represented, viz. *Ophiotrichoides* Ludwig (the species *O. Lymani* Ludwig, found at the Cape Verde Islands) and *Ophiopteron* Ludwig (the species *O. atlanticum* Koehler, found at the Senegal coast). There is, however, hardly any prospect of finding any of these genera in the British seas. (They are very easily distinguished from *Ophiothrix*, the former by the scales of the disk being entirely naked, *Ophiopteron* by having its arm spines webbed, connected by a thin, transparent skin.)

1. *Ophiothrix* Müller and Troschel.

Scales of disk more or less concealed by spines or thorny stumps, more rarely by grains. Arm spines rather long and somewhat glassy, distinctly thorny; in the distal part of arms the lowermost spine is transformed into a hook. In dried specimens a rather large hole is seen in the mid-line of each jaw, proximally to the adoral shields. Arms very brittle. Tube-feet closely set with sensory papillæ.

Two species are known from the British seas, but it is rather probable that three more will prove to occur there, namely, *O. quinquemaculata* (Delle Chiaje) (syn. *O. echinata* Müll. and Troschel), hitherto known with certainty only from the Mediterranean; *O. maculata* Ljungman (syn. *Ophiothrix inducta* Koehler),¹ known from the Josephina Bank, ca. 200 m. ("Josefina"), and off the Canaries, 410 m. ("Talisman"); and *O. indigna* Koehler, off Madeira, 150-370 m. ("Talisman"). The main distinguishing characters of these species are given in the key, with reference to the works, where full descriptions and figures are to be found.

Key to the species of Ophiothrix known from or likely to occur in the British seas.

1. Dorsal plates of arms with the distal edge more or less produced 2
- Dorsal plates of arms with the distal edge simply rounded 4
2. Middle of distal edge of dorsal plates raised into a knob, this giving the arms a keeled appearance 3
- Middle of distal edge of dorsal plates not raised, arms not keeled; arms flat; radial shields very large ("Talisman" *Oph.*, p. 298, Pl. xix. 17-19) *O. maculata* Ljungm.

¹ The author has had the type specimen of Ljungman's *Ophiothrix maculata* for examination and finds it identical with Koehler's *O. inducta* from the "Travailleur" and "Talisman" expedition.

3. Arm spines generally 7, increasing very gradually in length from the first to the fifth, then decreasing. Disk with spines or spinelets, not articulated to distinct tubercles

1. *O. fragilis* (Abildg.)

Arm spines generally 6, increasing very rapidly in length from first to fourth or fifth, the upper one being very much shorter.

Disk with strongly serrate spines, articulated to distinct tubercles. (Koehler, "Échinodermes," *Faune de France*, p. 72, Fig. 47) *O. quinquemaculata* (D. Ch.)

4. Dorsal plates of arms carrying small spines

2. *O. Lütkeni* Wyv. Thoms.

Dorsal plates of arms not carrying spines ("Talisman" *Oph.*, p. 296, Pl. xix. 22-26) *O. indigna* Koehler

1. *Ophiothrix fragilis* (Abildgaard). (Fig. 98.)

(Syn. *Ophiothrix alopecurus* Müll. and Trosch.; *O. Ferussacii* Müll. and Trosch.; *O. Rammelsbergii* Müll. and Trosch.; *O. rubra* Ljungman;¹ *Ophiocoma rosula* Forbes; *O. minuta* Forbes).

Disk covered with short spinelets or longer, slender spines, mostly both kinds intermingled. Oral side of disk only with short spinelets, the proximal part naked. Radial shields large, generally naked. Dorsal plates of arms naked, with a more or less distinct longitudinal keel; the outer edge more or less distinctly produced, often with a small elevated, whitish knob. Ventral plates almost rectangular, with a small depression proximally, the outer edge slightly concave. One small tentacle scale. Generally seven arm spines, increasing very gradually in length from the very small lowermost one to the fifth or sixth, then decreasing again. Disk often strongly projecting between the arms (depending on the state of development of the genital organs).

Reaches a size of ca. 20 mm. diameter of disk. Arms ca. five times the diameter of the disk. Colour in life exceedingly variable, from a uniform dark violet to almost white or reddish, spotted, often with arms banded.

This species is subject to very great variation, especially as regards the spines on the disk, the shape of the radial shields, and the length of the arm spines. This accounts for a number of "species" which can at most be regarded as varieties. Koehler, who has recently undertaken a detailed study of all these forms, distinguishes the following varieties: Var. *echinata* Delle Chiaje (non: Müller and Troschel), var. *pentaphyllum* (Ljungman),

¹ The author has had the opportunity of studying the type-specimen of Ljungman's *Ophiothrix rubra*, and finds it to be identical with *O. fragilis*.

var. *lusitanica* Ljungman, and var. *Abildgaardi* Koehler. To characterise all these varieties briefly is impossible, and as, moreover, they are by no means constant, and are connected by all intermediate forms, it may suffice to refer to the detailed descriptions given by Koehler in his "Échinodermes" in *Faune de France* (pp. 75-77), or in *Les Échinodermes des mers d'Europe* (i. pp. 267-77).

This very common species occurs mainly on hard bottom, and is often found in empty shells, among Serpulids, etc. ; also under stones on the shore. It is able to press itself into small cavities, from which it is hardly possible to remove it without breaking it to pieces, the more so as its arms very easily break off. Its food consists mainly of worms and Crustaceans, but it also eats small mussels, echinoderms, compound Ascidians, Foraminifera, etc.

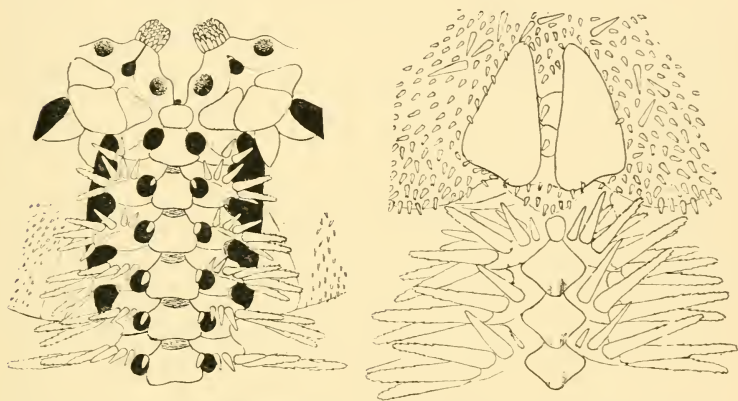


FIG. 98.—*Ophiothrix fragilis* ; part of oral and dorsal side. $\times 8$.

It appears that ciliary currents also play some rôle in catching food (detritus). It is eaten specially by *Luidia ciliaris*.

The larva (Fig. 88, 1) is very characteristic owing to its long, sideways-directed, postero-lateral arms, which are provided with 2-3 broad, dark pigment spots ; the other arms are short, unpigmented. Body skeleton (Fig. 87, 3) simple ; a small, unpaired process from the transverse rods. The quite young larva is peculiar through the postero-lateral arms being long already before any of the other arms have begun to appear ; the ciliated band accordingly goes in a nearly straight line across the body, above and below the mouth. On metamorphosis the long postero-lateral arms are not absorbed, but serve as a floating apparatus for the young brittle-star, which latter is very characteristic owing to its inrolled arms and its hook-shaped spines. When

ready for the bottom-life the young Ophiuroid throws off the larval arms, which remain connected together and still go on swimming for a little while, until the ciliated band disappears. The young brittle-star is characterised by having a large, naked, rather shining central plate; young specimens are also apt to roll in their arms on preservation.

The very remarkable statement has been made that this species may also develop in another way: directly, without any pelagic larva (Apostolidès); very likely this statement rests only on misunderstood observations. The same, evidently, holds good for the statement (Giard) that at certain times of the year it is viviparous.¹

In British seas *Ophiothrix fragilis* is very common all round the coasts, mainly in shallow water, down to ca. 150 m.; also recorded from the Rockall Bank. It is otherwise distributed from Lofoten and Iceland to the Mediterranean and the Azores, and apparently along the whole African coast down to the Cape. Its bathymetrical distribution is from the tide limit down to ca. 350 m.

2. *Ophiothrix Lütkeni* Wyv. Thomson. (Fig. 99.)

Disk with rather long spines, articulated to fairly distinct tubercles. Radial shields with scattered, much finer spines. Ventral side of disk with similar fine spines in a belt along the mid-line to the mouth shield. Dorsal plates of arms with outer edge rounded, not produced, without a longitudinal keel or at most with a very faint indication of a keel; they carry, in the proximal part of the arms, scattered, fine spines, which may, however, be wanting in younger specimens. Ventral plates mainly as in *O. fragilis*; one small tentacle scale. Arm spines slender, finely thorny, 8 in the proximal part of arm, gradually decreasing in number farther out; they increase very gradually in length upwards. Mouth shields transverse oval, distinctly broader than long, with a small peak within and without. It is a large and robust species, which reaches a size of ca. 25 mm.

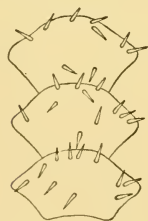


FIG. 99.—Dorsal plates of *Ophiothrix Lütkeni*.
× 6. (From Dan-
mark's Fauna.)

¹ The same author also has maintained that most other Ophiuroids of the Channel coasts are viviparous at certain times of the year, these times being not more nearly indicated. It appears that this is all due to erroneous observations, as is likewise the statement that they are also hermaphrodites.

diameter of disk and an arm length of ca. 150 mm. Colour in life pinkish, often with radiating whitish bands on the disk ; arms generally banded with pinkish and whitish.

Development and biology unknown.

In British seas this species is common in deeper water off S.W. Ireland, in depths of ca. 150-500 m. ; also recorded from the Lousy Bank, and likewise known from off the Shetland Islands.¹ It has elsewhere been found in the Bay of Biscay, where it is very common, between the Canaries and Cape Verde, and off the Azores. Bathymetrical distribution ca. 50-ca. 500 m.

III. Family OPHIUCOMIDÆ

Disk mostly covered with granules, which conceal both the scales and the radial shields. Both dorsal and ventral plates well developed. Arm spines erect. Mouth papillæ present. Each jaw carries a group of tooth papillæ and below these a series of strong teeth. Second pair of tube-feet inside the mouth edge.

Two genera of this family represented in British (and European) seas. The main genus of the family, *Ophiocoma*, so characteristic of the littoral region of tropical seas, is not represented in European seas, the statements in older literature of the occurrence of "*Ophiocoma tumida*" Müll. and Troschel in the Mediterranean resting on mistakes.

Key to the genera of Ophiocomidæ found in British and European seas.

- Disk granulated ; tentacle scales simple 1. *Ophiocomina* Koehler
 Disk not granulated ; inner tentacle scale much elongated, flattened,
 crossing that from the opposite side on the middle of the ventral
 surface of arm (Figs. 101, a, 102, a) . 2. *Ophiopsila* Forbes

1. *Ophiocomina* Koehler.

Disk completely covered by small granules. Arm spines simple, rather delicate, hollow, none of them especially elongate or club-shaped. Tentacle scales simple, none of them especially transformed. Teeth without a hyaline enamel-like cap.

Only one species in British and European seas, the only species known of this genus.

¹ The statement of the occurrence of this species off the Shetland Islands rests on information from Grieg that it was taken at the following localities by "Michael Sars" : 61° 3' N., 2° 13' E., 130 m. ; 61° 52' N., 1° 8' E., 220 m. ; and 61° 43' N., 1° 16' E., 190 m.

1. *Ophiocomina nigra* (Abildgaard). (Fig. 83, p. 145; Fig. 100.)

(Syn. *Ophiocoma nigra* (Abildg.); *O. granulata* Forbes;
O. Nilssoni Müll. and Troschel; *O. Raschi* G. O. Sars.)

Dorsal plates of arms broad, contiguous, with outer edge slightly rounded; the proximal ones sometimes covered or surrounded by granules. Ventral plates with a very obtuse inner angle, the outer edge rounded or slightly concave in the middle. Two tentacle scales, the outer one slightly the larger; in the distal part of arm only one, on a few of the proximal pores sometimes three tentacle scales. Arm spines 5-7, smooth, slender, about as long as two arm joints; the lower ones are slightly

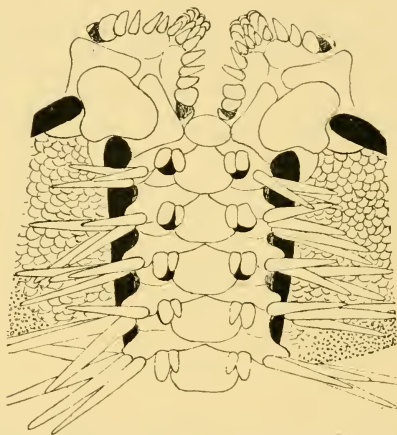


FIG. 100.—*Ophiocomina nigra*; part of oral side. $\times 8$.

shorter. Granules covering only the outer part of ventral side of disk, the scales being distinct on the inner part. Mouth shields as a rule broader than long, oval, with a rounded peak on outer side; they are, however, rather variable in shape. Diameter of disk up to 25 mm.; arms ca. five times as long as the diameter of disk. Colour in life varying much, from entirely black to brown or grey or even pink; often it is more or less spotted.

Ophiocoma Raschi G. O. Sars is the larger Atlantic form, not to be distinguished from the minor *O. nigra* of the Scandinavian seas, mainly the fjords, by any constant character, and can scarcely be maintained even as a variety.

The larva (Figs. 87, 1; 88, 2) is peculiar through having two pairs of ciliated lobes; body rods simple, end rods with one or

two inwardly-directed processes at the point. Colour of larva a faint yellowish.

This species is remarkable for its power of climbing; especially it climbs Laminarians, the huge leaves of which it may in places (at any rate at the Norwegian coast) literally cover up to the surface of the water. It often climbs the sides of aquaria, attaching itself there with a pair of its arms, its other arms stretched out under the surface of the water. The tube-feet are very strongly papillate; the slime secreted by these papillæ serves for attachment. The food appears to consist partly of plants (parts of the Laminarias), but it feeds also on all sorts of small animals. It is known to eat dead fishes, and it is sometimes found in great numbers on fishes caught in the nets. It is eaten by sea-stars and decapod Crustaceans, but apparently not by fishes. It prefers a stony bottom. It has been observed in places with a rather strong current to sit on the bottom with some of the arms stretched upwards, free in the water, apparently for the purpose of collecting food, which is probably caught in the slimy secretion of the tube-feet.

In British seas this species is common all round the south and west coasts; on the east coast it goes at least as far south as the Durham coast, while it does not appear to occur in the open North Sea. It is elsewhere distributed from the Trondhjem Fjord on the Norwegian coast down to the Azores and the Mediterranean. The bathymetrical distribution is 0-ca. 400 m., but it appears to be rather rare below ca. 100 m.

2. *Ophiopsila* Forbes.

(Syn. *Ophianoplus* M. Sars.)

Scales of disk not covered by granules; the scales are exceedingly fine, giving the impression of the disk being naked. Radial shields small, partly or wholly concealed by the scaling. Arm spines short, outstanding, flattened, but not otherwise specialised. The inner tentacle scale very long, flattened, dagger-shaped, crossing that of the opposite side in the mid-line on ventral surface of arm (Figs. 101, *a*; 102, *a*). Teeth with an enamel cap.

The elongate tentacle scales are covered with a thick, glandular, strongly ciliated skin; a band of this ciliated skin across the ventral side of the arm connects the two ciliated spines of each segment. These ciliated parts produce a current along the ventral side of the arm, which may perhaps have the function of leading food particles to the mouth. The ciliated spines, the lateral plates and, partly, the arm spines, are strongly luminescent,

the light, however, appearing only on irritation, chemical or mechanical.

Two species known from the British (and European) seas.

Key to the species of Ophiopsila represented in the British seas.

Arm spines 7 (6-8). Radial shields distinct, small, widely separated

1. *O. aranea* Forbes

Arm spines ca. 12. Radial shields not visible externally, wholly covered by the scales 2. *O. annulosa* (M. Sars)

1. *Ophiopsila aranea* Forbes. (Fig. 101.)

(Syn. *Ophianoplus marmoreus* M. Sars.)

Radial shields distinct, not covered with scales; they are small, linear, wide apart. Dorsal plates of arms elongate oval

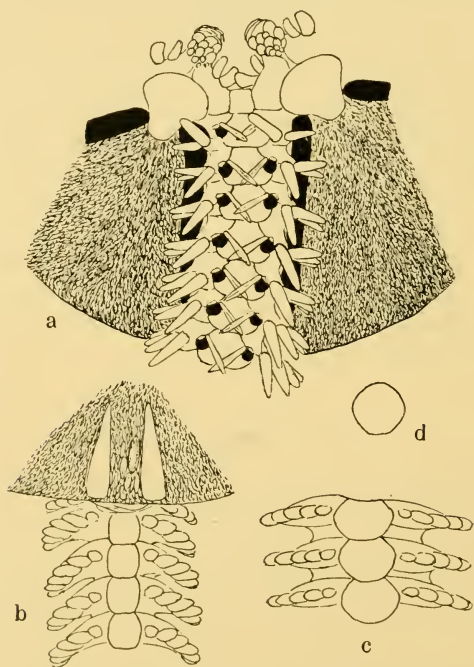


FIG. 101.—*Ophiopsila aranea*; part of oral side (a), of dorsal side, with basal part of arm (b), and of dorsal side of arm, from the middle (c); mouth shield of younger specimen (d). $\times 8$.

in proximal part of arm, farther out more rounded, broadly contiguous. Ventral plates with a slightly concave outer edge; they are also broadly contiguous. Mouth shields rounded, with a narrower outer lobe, in younger specimens simply rounded

(Fig. 101, *d*). Mouth papillæ two on each side of jaw, turning somewhat outwards. Arm spines 6-8, usually 7, the lower one slightly the longer. Disk up to ca. 12 mm. in diameter; arms very long, ca. seven times the diameter of the disk, somewhat thicker farther out than at their base. Colour in life reddish-brown, finely spotted with white. Arms more or less distinctly banded. The arms very easily break off, and also the whole disk is easily thrown off.

It prefers a hard bottom, where it conceals itself in all sorts of crevices; at Plymouth it is especially found in old crypts of Pholadids. Development unknown; at Plymouth its gonads were found to be ripe in August.

In British seas this species has been recorded only from off Plymouth (Mewstone Ledge, Stoke Point Grounds) in 27-36 metres. It is elsewhere distributed from the Channel to the Moroccan coast, the Azores, and the Mediterranean. The bathymetrical distribution is ca. 25-185 m.

2. *Ophiopsila annulosa* (M. Sars). (Fig. 102.)

(Syn. *Ophianoplus annulosa* M. Sars.)

Very much like the preceding species, but easily distinguished from it by the radial shields being wholly covered by the

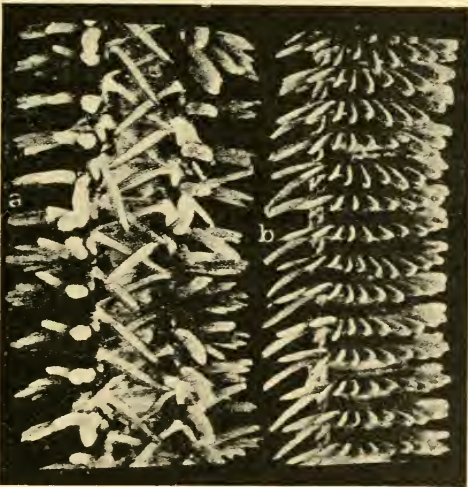


FIG. 102.—*Ophiopsila annulosa*; part of arm, ventral side (*a*), and in side view (*b*). $\times 6$. (After Koehler, *Faune de France*.)

fine scaling so as not to be visible externally, and by the more numerous arm spines, which are generally twelve; the lowermost are the longest.

Colour mainly as the preceding species, but the disk often with small whitish rings surrounding a darker spot ; arms banded with brownish and whitish. The colour (of both species) keeps fairly well in alcohol. This species upon the whole is somewhat coarser and appears to grow somewhat larger than *O. aranea*.

Biology probably as in the preceding species. Development unknown.

In British seas this species has hitherto been found only on the Irish west coast (Birterbury Bay, Kenmore Bay ; A. M. Norman).¹ It is elsewhere known only from the Mediterranean and from the Moroccan coast. Bathymetrical distribution ca. 60-100 m.

IV. Family OPHIACANTHIDÆ

Disk more or less closely covered by spines, stumps, or granules, which in a varying degree conceal the scales ; more rarely (*Ophiobes*) a thick, almost naked skin conceals the scales of the disk and even the arm plates. A continuous series of mostly pointed, papilliform, more rarely spine-like mouth papillæ ; a single, unpaired infradental papilla. A single series of pointed teeth, no tooth papillæ. Second pair of tube-feet inside the mouth edge. Spines erect, often very long. Arms often distinctly knotted, the proximal part of the segments being restricted, the distal part with the lateral plates swollen.

This family includes very numerous forms, and is one of the largest of the families of Ophiuroids. Most of them are deep-sea forms ; some of them (e.g. *Ophiomyces*, known from the North Atlantic) being among the most remarkable of Ophiuroids. They very often cling to corals, sponges, and the like, their arms being to some degree able to roll in ventrally ; this they often do also on preservation, which may make examination more difficult. They are probably detritus feeders, and are, on the whole,

¹ The author is inclined to think that A. M. Norman perhaps made a mistake in identifying the specimens from the localities on the Irish coast as *O. annulosa*. In his note, "Ophiopsila annulosa (M. Sars), a British Ophiurid" (*Ann. Mag. Nat. Hist.* (7) xiv. pp. 360-61, 1905), he states that he got this same species from Plymouth, where it had been found to be not uncommon in crevices of the red sandstone, especially in old Pholadidea crypts in 15-25 fms. on the Mewstone Ledge and Stoke Point Grounds. But this is exactly the locality of *Ophiopsila aranea*, which here grows to a very considerable size, just like *O. annulosa*. At the same time, however, Norman says that he regards *O. aranea* as a distinct species, characterised by its fewer arm spines. The matter is doubtful, and, until new records of the occurrence of *O. annulosa* in British seas are at hand, its presence there can scarcely be regarded as definitely settled.

rather sluggish animals. The development is unknown, excepting that some few of them (*Ophiomitrella clavigera* and *Ophiacantha anomala*, among British species) are viviparous (and hermaphrodites). One species, *Ophiacantha bidentata*, is known to be phosphorescent; it may well be supposed that this will hold good for several more of them.

Four genera are known to be represented in British seas, but several more have been found in the North Atlantic, and may be expected to occur also in the deep-sea off the British coasts, viz. *Ophioplinthaca* Verrill, with the species *O. carduus* (Lyman) (25° 49' N., 20° 12' W., 3015 m., "Challenger"; 30° 17' N., 43° 7' W., 3500 m., "Talisman"), and *O. chelys* Lyman (30° 38' N., 20° 12' W., 3015 m., "Challenger"; 39° 48' N., 12° 12' W., 3307 m., "Talisman"; 40° 58' N., 9° 40' W., 2271 m., "Princesse Alice"); *Ophiiothamnus* Lyman, with the species *O. affinis* Ljungman (Syn. *Ophioplinthaca occlusa* Koehler; *Ophioleđa minima* Koehler) (Bay of Biscay to off Madeira, 1220-1425 m., "Josephina", "Talisman", "Princesse Alice"); *Ophicamax* Lyman, with the species *O. dominans* Koehler (25° 29' N., 18° 22' W., 882 m., "Talisman"); *Ophiomedeä* Koehler, with the species *O. duplicata* Koehler (29° 52' N., 14° 4' W., 2075 m., "Talisman"; only one specimen known); *Ophiotrema* Koehler, with the species *O. Alberti* Koehler (38° 08' N., 23° 19' W., 4020 m., "Princesse Alice"; 42° 19' N., 23° 36' W., 4060 m., "Talisman"; also 51° 7' S., 9° 31' W., 3785 m., "Scotia"); *Ophiomyces* Lyman, with the species *O. frutectosus* Lyman (Azores, 575-1080 m., Josefinä Bank, 210-410 m., "Josefinä"), and *O. grandis* Lyman (Bay of Biscay, 392-608 m., "Talisman"); *Ophiolebes* Lyman, with the species *O. bacata* Koehler (32° 35' N., 17° 05' W., 1700 m., "Princesse Alice"; only one specimen known), and *O. relecta* (Koehler) (Syn. *Ophioscolex relectus* Koehler) (Bay of Biscay, 1410 m., "Caudan"; only one specimen known). The main characters of these genera are given in the following key to the genera of the family Ophiacanthidæ.

Key to the genera of Ophiacanthidæ known from or likely to occur in the British seas.

1. Radial shields usually large and distinct, mostly naked; rarely they are smaller and confined to edge of disk, in which case the scales carry large, globular stumps or granules 2
- Radial shields small, but distinct; scales of disk not with globular stumps or granules 5
- Radial shields totally covered by spines or scales, or by a thick skin, at most the outer end naked (in *Ophiotoma*, see Fig. 104) 6

2. Disk with a deep notch in the edge of each interradius . . . 3
 Disk without a notch in the interradial edge
 1. *Ophiomitrella* Verrill
3. Mouth papillæ long, spiniform; three spiniform tentacle-scales.
 Disk with strong spines *Ophiocamax* Lyman
 Mouth papillæ broad, scale-like, or papilliform; one tentacle
 scale 4
4. Disk with strong spines; three mouth papillæ on each side of
 jaw, the outer very broad *Ophiothamnus* Lyman
 Disk with thorny stumps; five mouth papillæ, the outer not
 distinctly wider than the others *Ophioplinthaca* Verrill
5. Tentacle pores large, with several (5-6) small, spine-like tentacle
 scales *Ophiotrema* Koehler
 Tentacle pores small, inconspicuous; only one tentacle scale
 Ophiacantha Müll. and Troschel (partly)
6. A rather thick skin covers both disk and arms, concealing the
 plates of both *Ophioteles* Lyman
 A rather thick skin covers the disk, leaving only end of radial
 shields free. Arms not covered by skin 2. *Ophiotoma* Lyman
 Neither disk nor arms covered by a thick skin 7
7. Mouth papillæ numerous, wide, flattened, turned outwards and
 arranged in two or more imbricating rows, covering the whole
 jaw *Ophiomyces* Lyman
 Mouth papillæ simple, usually in a single series, not arranged
 as above 8
8. Tentacle pores large, conspicuous, with two scales, one large,
 spine-like, at the inner corner and a small one at the outer
 side edge. Adoral shields with a long spine which covers the
 second tentacle pore. Disk scales distinct, each with a long,
 pointed spine *Ophiomedeia* Koehler
 Tentacle pores small, inconspicuous, with one or two equal-sized
 tentacle scales (or, rarely, more) at the inner corner. Adoral
 shields without spines 9
9. Dorsal plates of arms each divided into a small, rectangular
 proximal and a larger, rounded distal plate. Radial shields
 forming elongate crests, but covered by scales, as is the whole
 dorsal side of the disk, each scale carrying a short spine.
 Tentacle scale indistinct or none¹ 4. *Ophiochondrus* Lym.
 Dorsal plates of arms undivided
 3. *Ophiacantha* Müll. and Troschel (partly)

The species of those genera not yet known from the British seas, which include more than one North Atlantic species, are thus distinguished:

¹ These characters fit the British species *Ophiochondrus armatus* (Koehler), but not the genus *Ophiochondrus* in general. In fact it is very doubtful whether the British species is justly referred to this genus. (See below, p. 196, under *O. armatus*.)

Ophioplinthaca Verrill.

- Tentacle scale, beyond the first pair, cleft or strongly thorny. Radial shields scarcely sunk *O. carduus* (Lyman)
 Tentacle scale simple, smooth; radial shields usually deeply sunk
 *O. chelys* (Lyman)

Ophiomyces Lyman.

- Mouth papillæ in two fairly regular series along each side of jaw; ventral plates of arms narrow, longer than broad; usually two tentacle scales (*Illustr. Catalogue Mus. Comp. Zool.* vi. 1871, Pl. V. 11-13) *O. frutectosus* Lym.
 Mouth papillæ more irregularly arranged; ventral plates of arms distinctly broader than long; usually three tentacle scales.
 ("Challenger" *Oph.*, Pl. XIX. 13-15) *O. grandis* Lym.

Ophiolebes Lyman.

- Disk with coarse granules, also on the prominent radial ridges.
 Five arm spines. (*Bull. Inst. Oceanogr.* No. 396, Fig. 1)
 *O. bacata* Koehler
 Disk with granules, but radial ridges nearly naked. Six to seven arm spines ("Caudan", Pl. III. 31) *O. resecta* (Koehler)

1. *Ophiomitrella* Verrill.

Disk set with short, thick stumps or glassy granules, which do not conceal the scales. Radial shields large and distinct, naked. Tentacle pores small and inconspicuous; one simple tentacle scale. Mouth papillæ simple, papilliform.

One species is known from the British seas, but another, *Ophiomitrella globulifera* (Koehler), hitherto found only in the Bay of Biscay, 1700 m. ("Caudan"), and between the Canaries and Cape Verde, 930-1475 m. ("Talisman"), is very likely to occur also in the British region of the Atlantic deep sea.

Key to the species of Ophiomitrella known from or likely to occur in the British seas.

- Disk set with short, thick stumps; radial shields contiguous; scales of disk overlapping; ventral plates of arms widely separated 1. *O. clavigera* (Ljungm.)
 Disk with glassy granules; radial shields separated by a wedge of scales; the scales of disk separated by furrows; ventral plates of arms contiguous *O. globulifera* (Koehler)

1. *Ophiomitrella clavigera* (Ljungman). (Fig. 103.)

(Syn. *Ophiactis clavigera* Ljungman; *Ophiolebes claviger* (Ljungman);
Ophiomitrella cordifera Koehler; *Ophiolebes acanellæ* Verrill.)

Scales of disk simply imbricating, carrying short, thorny stumps. Radial shields contiguous. Dorsal plates of arms small, rhombic, widely separated by the lateral plates which join in the mid-line. Ventral plates with slightly excavated outer edge, generally widely separated; sometimes, however, the proximal ones are almost contiguous. Five to six arm spines, the upper ones of which are the longest, somewhat longer than an arm segment; they may, however, be somewhat shorter and thicker than shown in the

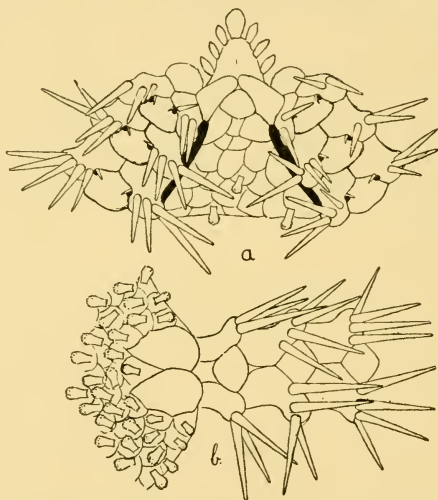


FIG. 103.—*Ophiomitrella clavigera*. (a) Part of oral, (b) of dorsal, side.
 × 9. (After Th. Mortensen, *Scand. Echinod.*)

figure, also they are more or less serrate. One small tentacle scale. Mouth shields small, rhombic, or more or less irregular. Adoral plates large. The disk is, in adult specimens, as a rule much swollen. It reaches a size of ca. 7 mm. diameter of disk; the rather robust arms are 4-5 times the length of the diameter of disk. Colour in life unknown; in alcohol, whitish.

This species is viviparous, and a proterandric hermaphrodite. A remarkable (undescribed) Crustacean with four egg-sacs lives as a parasite in it; the infected specimens are totally castrated by the parasite.

In British seas this species has been found off S.W. Ireland in

ca. 1100-1400 m. ("Helga"). It is further known from the Skagerrak and off the Azores and Madeira, and from W. Greenland to S. Carolina. The bathymetrical distribution is ca. 250-ca. 1500 metres.

2. *Ophiotoma* Lyman.

(Syn. *Ophiopora* Verrill.)

A rather thick skin covers the scales of the disk, leaving only the outer end of the radial shields naked. Arms not covered by thick skin, the arm plates being distinct. Tentacle pores rather large; no tentacle scale, except at the pore of the second mouth tentacle. Mouth papillæ simple, papilliform.

Only one species known from British (and European) seas.

1. *Ophiotoma coriacea* Lyman. (Fig. 104.)

Disk rather thick, the small scales being hardly visible through the skin, though more distinct on the oral side. A few scattered

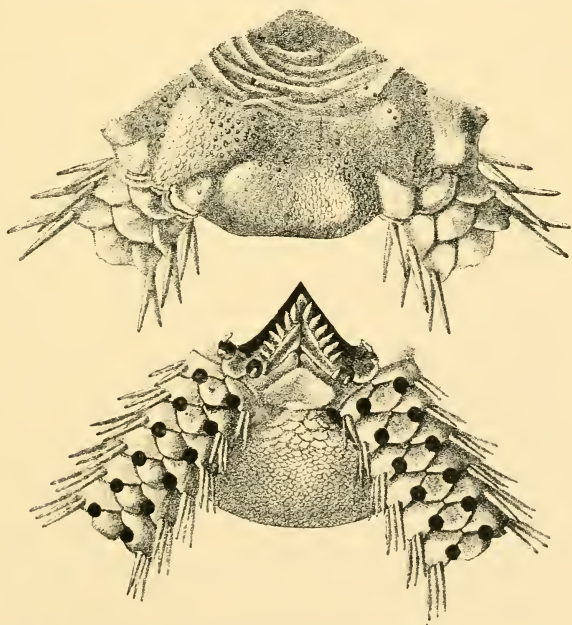


FIG. 104.—*Ophiotoma coriacea*; part of dorsal and oral side. $\times 3$.
(After Lyman, "Blake" *Oph.*)

spinelets are found on the disk. Dorsal plates of arms contiguous, with outer edge convex; ventral plates separated by

the lateral plates, with convex outer edge. Arm spines 4-5, slender, smooth. Mouth shield wide triangular, with rounded corners. Mouth papillæ 5-6 to each side of jaw. Reaches a considerable size, ca. 17 mm. diameter of disk, the arms being ca. five times as long as the diameter of disk. Colour in alcohol greenish-grey on disk; arms pale brown.

In British seas this species has been found only at 51° 22' N., 12° 41' W., 1765 m. ("Helga"). It is elsewhere known from off the Azores ("Princesse Alice") and from the West Indies ("Blake"). Bathymetrical distribution 530-3465 m.

3. *Ophiacantha* Müller and Troschel.

(Syn. *Ophiolimna* Verrill.)

Disk covered with fine thorns or stumps; radial shields wholly covered or just the outer end visible, or quite small, but distinct. Tentacle pores small and inconspicuous, with one or two simple tentacle scales. Mouth papillæ simple, papilliform.

Six species of this genus are known from the British seas, but several more are very likely to occur there also, viz. *O. anomala* G. O. Sars (known from Norway, Greenland, and off Nova Scotia, ca. 200-1400 m.); *O. Bairdi* Lyman ("Talisman," 2400-2600 m.; locality not given; known elsewhere from off the Atlantic coast of U.S. America, and widely distributed in the North Pacific; bathymetrical distribution ca. 620-2600 m.); *O. brevispina* Koehler (only one specimen known, from Bay of Biscay, 166 m. ("Hirondelle")); *O. composita* Koehler (syn. *O. simulans* Koehler) (Bay of Biscay, off the Canaries, 1480-2083 m., "Caudan," "Talisman"; also the Indo-Pacific, ca. 700-2800 m.); *O. cuspidata* Lyman (off Ascension, 785 m., "Challenger"; Mediterranean, 2460 m., "Princesse Alice"); *O. decipiens* Koehler (off the Azores, 1257 m., "Talisman"; only one specimen known); *O. hirsuta* Lyman (off Madeira, 1500 m., "Princesse Alice"; otherwise known from the West Indies, ca. 150-ca. 800 m.); *O. lineata* Koehler (off the Azores, 1165 m., "Princesse Alice"; also off Florida, 490-990 m.); *O. mesembria* H. L. Clark (syn. *O. meridionalis* Koehler (non Lyman), *O. pentagona*, var. *armata* (Koehler) (off Azores, 2870 m., "Hirondelle"; otherwise known from the W. Indies, ca. 250-1125 m.); *O. nodosa* Lyman (S. of Canaries, 3145 m., "Challenger"; only one specimen known); *O. notata* Koehler (off N.W. Spain, 1226 m., "Talisman"; only one specimen known); *O. opercularis* (Koehler) (syn. *Ophiolimna opercularis* Koehler) (12° 7' N., 33° 33' W., 6035 m., "Princesse Alice"; only one specimen known);

O. parvita Koehler (off Cape Verde, ca. 600 m., "Talisman"; only one specimen known); *O. rosea* Lyman (Bay of Biscay, 1410-1700 m., "Caudan"; otherwise known from the Indo-Pacific, 315-1400 m.); *O. setosa* Müll. and Troschel (Bay of Biscay to S. of the Canaries; Mediterranean, ca. 50-1480 m.); *O. Smitti* Ljungman (off Portugal, 1420 m., "Josefina"; only one specimen known); *O. Valenciennesi* Lyman (Azores, Cape Verde, 640-1440 m., "Talisman", "Princesse Alice"; also the Malayan Ocean, ca. 200-1900 m.); *O. veterna* Koehler (Azores, Madeira, 1968-2200 m., "Princesse Alice"). The main characters of all these species are given in the following key. On account of the difficulty in sufficiently characterizing these numerous species in the short terms of a key, where the use of some relative characters cannot easily be avoided, reference is also given to figures in some main works representing these various species; in order to make sure of the identification of such species as are mentioned only in the key, it will be necessary to compare them with the figures and descriptions in the works quoted.

Key to the species of Ophiacantha known from or likely to occur in the British seas.

1. Two tentacle scales at one, two, or more of the proximal pore pairs 2
 One tentacle scale, also at the proximal pore pairs 5
2. Only first pore pair with two tentacle scales; radial shields in a furrow; disk with small stumps ending in a crown of 5-6 thorns; ventral plates contiguous. 8 arm spines. ("Challenger" *Ophiuroidea*, Pl. XV. 9-10) *O. cuspidata* Lym.
 The two proximal pore pairs, or more, with two tentacle scales 3
3. Disk evenly granulated; ventral plates contiguous. 7 slender, flattened arm spines. ("Challenger" *Oph.*, Pl. XXVI. 7-8) *O. Valenciennesi* Lym.
 Disk with spines 4
4. Arm spines 6, flattened, serrate; mouth shields wider than long, without spines. ("Hassler" *Oph.*, Pl. II. 21-23) *O. hirsuta* Lym.
 Arm spines 8, smooth, not flattened; mouth shield longer than wide, with spines along the outer edge (Fig. 105, 3, 4) 1. *O. spectabilis* G. O. Sars
5. Mouth papillæ 5 or more on each side of jaw; supplementary papillæ may be present on apex of jaw or at the adoral plates 6
 Mouth papillæ 3-4 on each side of jaw; no supplementary papillæ 9

6. Arm spines 11. ("Challenger" *Oph.* Pl. XXV. 11-12)
O. rosca Lyman
 Arm spines 6-7 7
7. Radial shields forming elevated ridges; disk with granular stumps. ("Monaco", xxxiv. Pl. XXIX. 3-4) *O. veterna* Koehler
 Radial shields not forming elevated ridges 8
8. Disk with granules and spines. ("Blake" *Oph.* Pl. V. 70-72)
O. Bairdi Lyman
 Disk with granular stumps 6. *O. bidentata* (Retz.) (*pro parte*)
9. Radial shields forming elevated ridges 10
 Radial shields not forming elevated ridges 13
10. Disk naked, radial ridges covered with stumps; 7-8 arm spines.
 ("Monaco", xii. Pl. VIII. 37-38) . *O. setosa* Müll. and Trosch.
 The whole disk covered with short stumps or spines 11
11. Some slender spines scattered among the stumps on disk and radial shields; 6 arm spines¹ *O. Smitti* Ljungm.
 No spines on disk, only a uniform covering of small stumps . . . 12
12. Ventral side of disk without stumps, the scales distinct; five short arm spines; outer mouth papilla not much enlarged.
 ("Monaco", xii. Pl. VIII. 43, IX. 44) *O. brevispina* Koehler
 Ventral side of disk with stumps; 7-8 arm spines; outer mouth papilla broad, scale-like. (*Bull. U.S. Nat. Mus.* 84, Pl. IX. 1-2, *O. meridionalis*) *O. mesembria* H. L. Clark
13. Disk with sparse, rather coarse spinelets, which do not conceal the scales 14
 Disk with short stumps or grains or a close coat of fine spinelets, which conceal the scales 15
14. Mouth papillæ small conical. ("Talisman", Pl. XX. 31-32)
O. decipiens Koehler
 Mouth papillæ large, flattened (Fig. 106) 2. *O. crassidens* Verrill
15. Radial shields naked and distinct, though small 16
 Radial shields covered, at most outer end distinguishable . . . 17
16. Ventral plates contiguous; tentacle scale about as long as the ventral plate, slender, serrate; mouth shield longer than broad, almost rectangular. ("Talisman", Pl. XX. 36-38)
O. notata Koehler
 Ventral plates separated; tentacle scale broad, not as long as ventral plate; mouth shield about as broad as long, with an outer lobe. ("Talisman", Pl. XX. 33-35) *O. parvita* Koehler
17. Arm plates with fine, but distinct, parallel transverse lines.
 ("Monaco", xxxiv. Pl. XXV. 6-8) . . . *O. lineata* Koehler
 No transverse lines on arm plates 18
18. The outer (4th) mouth papilla very broad and scale-like, meeting that of the opposite side so as to close the outer end of mouth slit. Some granules on middle of jaw. Disk with smooth granules. ("Monaco", xxxiv. Pl. XXVII. 9-10)
O. opercularis (Koehler)

¹ This species has never been figured.

- Not as above 19
19. Disk covered with stumps with a crown of 7-8 thorns 20
 Disk covered with grain-like stumps or with fine spinelets
 terminating simply or in three thorns 22
20. Outer (3rd) mouth papilla broad, the two inner simple, spiniform ;
 tentacle scale small, spiniform. ("Investigator" *Oph.* Pl. VIII.
 66 ; "Siboga", *Oph.* Pl. XXIII. 7) *O. composita* Koehler
 All three mouth papillæ simple, spiniform ; tentacle scale long,
 serrate (Fig. 107) 21
21. Mouth papillæ long and slender, spine-like. ("Challenger", *Oph.*
 Pl. XXII. 1-4) *O. nodosa* Lym.
 Mouth papillæ shorter, simply papilliform¹ 3. *O. aristata* Koehler
22. Disk with a dense covering of fine spinelets 23
 Disk with grain-like stumps 24
23. Spinelets of disk ending in some (three or more) fine thorns ;
 dorsal arm plates cup-shaped ; mouth shields with a pro-
 nounced outer lobe ; 6-8 arm spines (Fig. 105, 5-6) 4. *O. abyssicola* G. O. Sars
 Spinelets of disk simple ; dorsal arm plates triangular ; mouth
 shields with convex outer edge or with a very obtuse outer
 lobe ; 4 arm spines (Fig. 108) 5. *O. densa* Farran
24. Arms 6 (rarely 7 or 5) ; mouth shields as long as broad (Fig. 105,
 7-9) *O. anomala* G. O. Sars
 Arms 5 ; mouth shields broader than long (Fig. 105, 1-2) 6. *O. bidentata* (Retzius)

1. *Ophiacantha spectabilis* G. O. Sars. (Fig. 105, 3-4.)

Disk covered with rather coarse spines, on the dorsal side ca. 2 mm. long, on the ventral side shorter, more like granules. Radial shields quite concealed. Dorsal arm plates triangular, contiguous at base of arm, in larger specimens a good way out on the arms. Ventral plates almost contiguous, not broader than long, with convex outer edge. The proximal 2-3 pairs of pores each with two tentacle scales, those beyond with only one large and broad tentacle scale. Arm spines 8, farther out 6-5 ; they are smooth, compressed, increasing somewhat in length towards the dorsal side, the uppermost ones being as long as 2-3 arm segments ; they almost join in the dorsal mid-line for a good distance out on the arms. Mouth papillæ usually 4 on each side of jaw, in larger specimens more, as many as 8. Mouth shields rounded, prolonged outwards, provided with some short spines

¹ *O. nodosa* and *aristata* evidently are very closely related and perhaps will prove to be identical.

along the outer edge. Colour in life yellowish-white. Reaches a considerable size, ca. 15 mm. diameter of disk; arms ca. 4-5 times that length.

In British seas this species has been found only in the Faroe

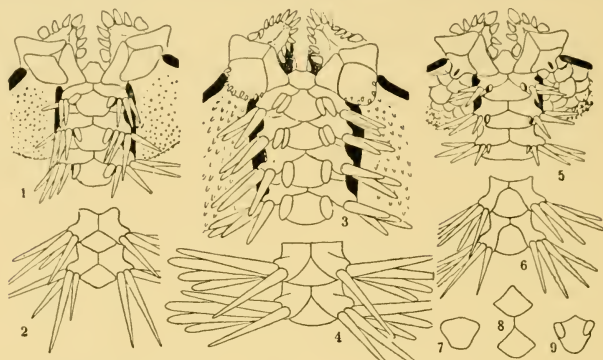


FIG. 105.—1-2. *Ophiacantha bidentata*. 3-4. *O. spectabilis*. 5-6. *O. abyssicola*; part of the oral side and arm segments from dorsal side. 7-9. *O. anomala*. 7. Mouth shield. 8. Two dorsal arm plates. 9. Ventral plate, with the tentacle scales. $\times 5$. (From *Danmark's Fauna*.)

Channel (60° 11' N., 8° 15' W., 780 m., "Triton"). It is elsewhere known from Lofoten and the Trondhjemfjord on the Norwegian coast, from the Bay of Biscay, 800-1700 m. ("Caudan"), and from the east coast of N. America. Bathymetrical distribution ca. 150-1700 m.

2. *Ophiacantha crassidens* Verrill. (Fig. 106.)

Disk with spines or crochets, which are slightly roughened and bi- or trifid at the tip; the scales of the disk distinct. Radial shields may be distinct; they are very small, widely separated by several rows of scales. Dorsal arm plates small, triangular, well separated even at base of arm; ventral plates with convex outer edge, separated. One fairly large, oval tentacle scale. Six or seven arm spines, the three lower flattened and bearing several hooked spinules distally on their lower edges, the upper ones round, almost smooth; the longest, the uppermost but one, equals about $2\frac{1}{2}$ arm segments in length. The mouth papillæ three on each side of jaw, large and flattened; the papilla on apex of jaw is the largest; it is slightly furrowed longitudinally and slightly overlapped by the other papillæ. The mouth shield is triangular, with the outer edge slightly concave (the shield being thus heart-shaped) or convex. Colour in life not recorded,

in alcohol dark brown. A rather robust species reaching a size of at least 12 mm. diameter of disk. Length of arms ca. 4 times diameter of disk.

In British seas this species has been found off S.W. Ireland, in

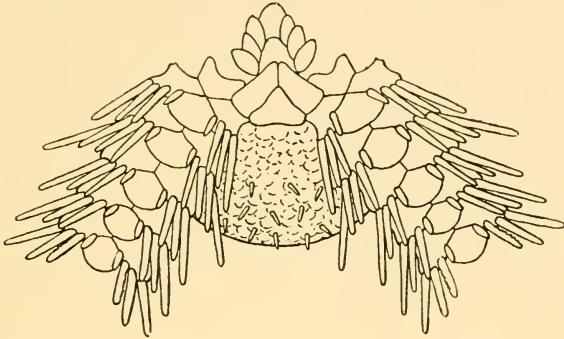


FIG. 106.—*Ophiacantha crassidens*; part of oral side. (After Farran, *Deep-Water Ast. . . . Ireland.*) \times ca. 6.

ca. 970-1770 m. ("Helga"). It is elsewhere known from off the Azores ("Princesse Alice"), from $45^{\circ} 26' N.$, $25^{\circ} 45' W.$, 3120 m. ("Michael Sars"), and from off Cape Hatteras, N.E. America. Bathymetrical distribution ca. 970-3120 m.

3. *Ophiacantha aristata* Koehler. (Fig. 107.)

Disk covered with rather coarse stumps ending in a crown of 7-8 spines, which may be arranged so as to form a cross. Scales

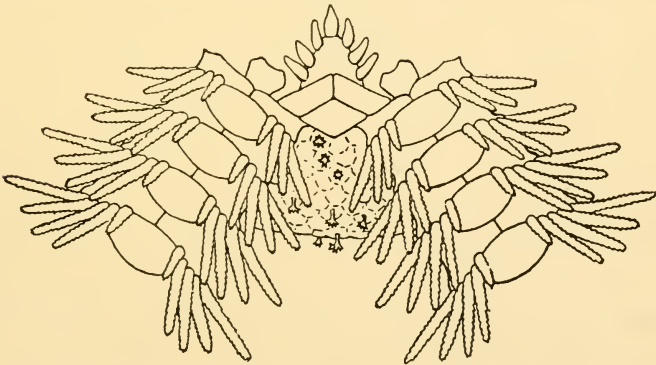


FIG. 107.—*Ophiacantha aristata*; part of oral side. (After Farran, *Deep-Water Ast. . . . Ireland.*) \times ca. 6.

of disk and radial shields not distinct. Dorsal arm plates very small, triangular with convex outer edge, widely separated even

at base of arm. Ventral plates with convex outer edge, fairly close together, the proximal ones may even be contiguous. One long, spine-like, thorny tentacle scale, which may be flattened. Eight thorny arm spines, the upper ones more slender, about as long as three arm segments. Three to four mouth papillæ on each side of jaw, not specially widened. Mouth shield rhombic or somewhat prolonged outwards. Colour not recorded. Arms ca. six times the diameter of disk, which does not appear to surpass 9 mm.

In British seas this species has been taken off S.W. Ireland in ca. 1100-1280 m. ("Helga"). It is elsewhere known from the Bay of Biscay, the Azores, and down to S. of the Canaries. Bathymetrical distribution ca. 820-1740 m.

This species is so near to *O. nodosa* Lym. that it is rather likely to prove identical therewith, in which case the name *nodosa*, as the oldest, should be used for it.

4. *Ophiacantha abyssicola* G. O. Sars. (Fig. 105, 5, 6.)

(Syn. *Ophiacantha millespina* Verrill.)

Disk closely covered with fine spinelets ending in some fine thorns, giving a somewhat velvety appearance; neither scales nor radial shields distinct. Under side of disk without spinelets in the proximal part, the scales being here distinct. Dorsal arm plates of a very characteristic cup-shape, the side edges being bent in the shape of an S. Ventral plates distinctly broader than long, with straight outer edge; both dorsal and ventral plates widely separated. One small tentacle scale. Arm spines 6-8, slender, delicate, finely thorny, the upper ones the longest, equalling two arm joints in length. The spines may join in the mid-dorsal line at the base of arms. The distal end of the arm joints rather swollen. Three to four mouth papillæ, the outer one somewhat widened. Mouth shields almost cross-shaped, with a groove in the outer lobe. Colour in life yellowish-brown, the oral tentacles dark brownish-red, giving the living specimens a rather characteristic appearance. Disk scarcely surpassing 7 mm. in diameter, arms five to six times as long as the diameter of disk.

In British seas this species has been taken in the Faroe Channel ("Porcupine") and off the W. Coast of Ireland ("Helga") in 520-990 m. It is elsewhere known from Lofoten to Hardangerfjord on the Norwegian coast, from the Bay of Biscay, the Azores, farther from Greenland and the east coast of N. America. Bathymetrical distribution ca. 35-3500 m.

5. *Ophiacantha densa* Farran. (Fig. 108.)

Disk closely covered with small rod-like glassy spinules, which are only slightly bifid or trifid at the tip; scales of disk, as well as radial shields, not visible. Dorsal arm plates small, triangular, with convex outer edge, widely separated even at base of arm. Ventral plates with almost semicircular outer edge, widely separated. 1 small, smooth tentacle scale. 4 slender, smooth

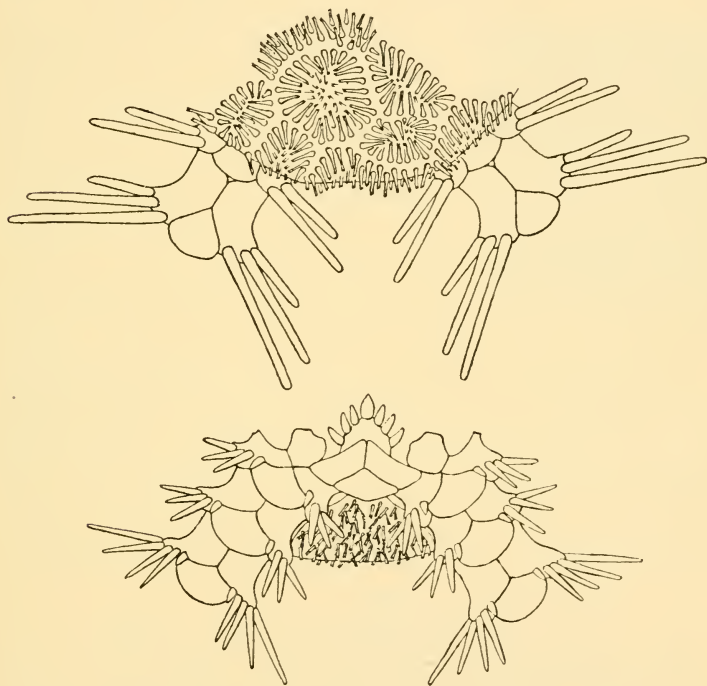


FIG. 108.—*Ophiacantha densa*; part of dorsal (upper figure) and oral side (lower figure). (After Farran, *Deep-Water Ast. . . . Ireland.*) \times ca. 6.

arm spines, the uppermost at base of arm as long as two arm joints. 3 subequal mouth papillæ. Mouth shields lozenge-shaped, with a convex outer edge. Colour in life not recorded. Diameter of disk up to 4.5 mm., by an arm length of ca. 20 mm.

This species has till now been found only in the British seas, off S.W. Ireland (50° 39' N., 11° 14' W., 50° 42' N., 11° 18' W., 53° 7' N., 14° 50' W., in depths of ca. 740-1310 m., "Helga").

6. *Ophiacantha bidentata* (Retzius). (Fig. 105, 1, 2.)

(Syn. *Ophiacantha spinulosa* Müll. and Troschel; *O. hibernica* Farran.)

Disk closely covered with short stumps, also on the ventral side; neither scales nor radial shields distinct. Dorsal arm plates rhomboidal or with convex outer edge, well separated. Ventral plates with convex or slightly excavated outer edge, well separated from base of arm. One rather large tentacle scale. Six to eight slender, rather smooth arm spines, increasing in length towards the dorsal side, the longest equalling 3-4 arm joints in length. At base of arms the spines often join in the mid-dorsal line. Three to four (or as many as 6) mouth papillæ; the outer ones may be widened. Sometimes also some supplementary papillæ on apex of jaw or outside, at the adoral plates. Mouth shields distinctly broader than long, with a very obtuse outer lobe. Colour in life dark brownish. Arms ca. 3-5 times as long as diameter of disk, which may be as much as 12 mm.

It is a rather variable species, which is, however, easily distinguished from the other species of the N.E. Atlantic. It is known to be phosphorescent.

In British seas this species has been found in the Faroe Channel, 690-790 m. ("Porcupine"), and off S.W. Ireland, 1765 m. ("Helga", recorded under the name of *O. hibernica* Farran). It is known elsewhere from the Arctic regions—it is circumpolar—down to the Azores and Cape Verde, and on the American east coast down to 33° N. In the Pacific it goes as far south as Japan. Bathymetrical distribution ca. 10-4500 m.

4. *Ophiochondrus* Lyman.

Disk set with short spines or stumps, which do not conceal the rounded, not imbricating, scales. Radial shields forming more or less distinct elongate ribs. Dorsal arm plates divided. Mouth papillæ simple, spiniform. Tentacle scales indistinct or none.

This diagnosis fits the European species, *O. armatus*, but not the genus *Ophiochondrus* proper. In fact this species, in the opinion of the present author, does not properly belong to the genus *Ophiochondrus* any more than to the genus *Ophioplus*, to which it was at first referred. It ought rather to form a separate genus; but as this is not a fit place for establishing a new genus, it may still be named *Ophiochondrus* here; but it should not be forgotten that it is, at least, very doubtful whether it is justly referred to

this genus. While *Ophiochondrus* is usually referred to the family *Hemieuryalidae* or to a separate subfamily *Ophiochondrinæ*, *O. armatus*, in the opinion of the present author, is a true Ophiacanthid.

1. *Ophiochondrus armatus* (Koehler). (Figs. 109-110.)

(Syn. *Ophioplus armatus* Koehler.)

Scales of dorsal side small, rounded, not imbricating, each carrying a short spine. The radial shields also covered by such scales, leaving only a small part at the distal end free. Dorsal arm plates divided into a larger outer part, with strongly convex outer edge, and a smaller, more or less rectangular, inner part. A membranous space separates the dorsal plates of each two consecutive joints (Fig. 110, 2). The dorsal plates are thus divided into two nearly to the end of the arm. Ventral plates somewhat broader without than within, with straight outer and inner edge, also separated from each other by a membranous space. Tentacle pores very small, only the three proximal pairs distinct. No tentacle scale present (on the specimens in hand). Five to seven short, smooth, outstanding arm spines



FIG. 109.—*Ophiochondrus armatus*; dorsal side. Slightly enlarged.

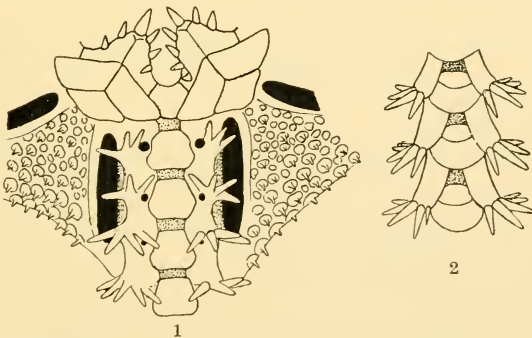


FIG. 110.—*Ophiochondrus armatus*; part of oral side (1) and three arm joints, dorsal side. $\times 9$.

of about equal length. Three (2-4) small mouth papillæ on each side of jaw. Mouth shields broader than long, with an obtuse outer lobe. Adoral shields very broad, not prolonged outwards.

Colour in life not known. Reaches a size of ca. 7 mm. diameter of disk. Arms ca. four times that length. It appears that the arms and spines are covered with a fairly thick skin.

Development unknown. It appears to live on corals or the like, to which it is able to cling by means of its arms, which can be rolled in ventrally, as in several other Ophiacanthids.

In British seas this species has been found at 51° 26' N., 11° 45' W., 990 m., 22, v. 1914, S.R. (50 m. S.S.W. of Skellig's, Co. Kerry). (Not recorded previously.) It is elsewhere known from off the Azores, 1250 m. ("Princesse Alice"). Also from the West Indies it is recorded ("Albatross"), but it may perhaps not be quite indubitable whether it is really this same species.

V. Family OPHIACTIDÆ

Disk often with spines or granules, which do not, as a rule, conceal the scales. Mouth papillæ usually not contiguous with the infradental papillæ. A single series of square teeth, no tooth papillæ. Second pair of tube-feet inside the mouth edge. Spines short, outstanding. Genital organs in one large mass at each bursal slit.

Three genera known from the British seas, but a fourth is likely to be represented there also, viz. *Amphiactis* Matsumoto, with the species *A. duplicata* (Lym.) (Syn. *Amphiura*, *Ophiactis duplicata* Lym.), known from the Bay of Biscay, off the Azores and Cape Verde, 628-2178 m.; it is elsewhere known from the West Indies, and also widely distributed over the Pacific (ca. 135-2870 m.).

Key to the genera of Ophiactidæ known from or likely to occur in the British seas.

- | | |
|--|---|
| 1. No genital slits ¹ | 2. <i>Ophiopus</i> Ljungm. |
| Genital slits present | 2 |
| 2. Dorsal plates of arms each surrounded by a circle of small plates | 3. <i>Ophiopholis</i> Müll. and Trosch. |
| Dorsal plates of arms not surrounded by small plates | 3 |
| 3. One or two mouth papillæ on each side of jaw, not contiguous with the infradental papilla | 1. <i>Ophiactis</i> Lütken |
| Four to five papillæ on each side of jaw, contiguous with the infradental papilla ² | <i>Amphiactis</i> Matsumoto. |

¹ The Mediterranean species, *Ophiactis virens* (M. Sars), also lacks the genital slits. It is at once distinguished from the 5-armed *Ophiopus* by having 6-7 arms, and by being self-dividing, half the disk and the corresponding arms being usually about to regenerate.

² This genus is otherwise usually referred to the family Amphilepidæ, but, in the opinion of the present author, it undoubtedly belongs to the Ophiactidæ.

1. *Ophiactis* Lütken.

Disk generally with scattered spines, which do not conceal the rather coarse scales. One to two mouth papillæ, not contiguous with the generally heart-shaped infradental papilla on apex of jaw. No small plates around the dorsal arm plates. Arm spines rather short, not very coarse, none of them hook-shaped. Genital slits usually well developed.

The species of this genus are mostly small forms; several of them propagate by autotomy, and are therefore usually found with one half of the disk and the corresponding arms about to regenerate, and conspicuously smaller than the other half of the disk and its arms. These self-dividing species usually have 6 or 7 arms.

Two species have been found in the British seas, but some more are likely to occur there also, namely: *Ophiactis canotia* Lyman (off Azores, 1800 m., "Challenger"); *O. echinata* Koehler (Azores, 800 m., "Hirondelle"; only one specimen known); *O. Lymani* Ljungman (15° 54' N., 22° 55' W., 91 m.; elsewhere known from the West Indies); *O. profundæ* Lütken and Mrtsn. (Azores, 650-914 m., "Princesse Alice"; elsewhere known from the Pacific, ca. 1000-1650 m.); *O. nidarosiensis* Mrtsn. (hitherto known with certainty only from the Norwegian coasts, ca. 200 m., but very probably the specimen from the Azores recorded as *Ophiactis hirta* Lym. ("Princesse Alice", 1095 m.) was really *O. nidarosiensis*). Also the Mediterranean species, *O. virens* M. Sars, which occurs likewise at the Azores and down to Cape Verde, may be mentioned, though, as a strictly littoral form, it is not very likely to occur as far north as the British coasts. The main characters of these species are given in the following key.

Key to the species of Ophiactis known from or likely to occur in the British seas.

- | | | |
|---|------------------------------|---|
| 1. Arms 5 | | 2 |
| Arms 6-7 | | 5 |
| 2. One mouth papilla on each side of jaw (Fig. 112) | | |
| | 1. <i>O. Balli</i> (Thomps.) | |
| Two mouth papillæ on each side of jaw | | 3 |
| 3. Dorsal plates of arms triangular, widely separated. ("Monaco", xii. Pl. V. 15-16) ¹ | | |
| | <i>O. echinata</i> Koehler | |
| Dorsal plates of arms contiguous in proximal part of arms | | 4 |

¹ The single specimen known of *O. echinata* is a young one, measuring only 2 mm. diameter of disk. It may possibly be only the young of one of the other species known from the European seas.

4. Dorsal plates of arms fan-shaped, with convex outer edge ; spines on dorsal side of disk ; radial shields not very broad (Fig. 114)
 2. *O. abyssicola* M. Sars
 Dorsal plates rhombic, outer edge with a rounded peak ; no spines on dorsal side ; radial shields very broad. ("Challenger" *Oph.* Pl. XIX. 16-18) *O. canotia* Lyman
5. Radial shields contiguous in distal half *O. Lymani* Ljungm.
 Radial shields separate 6
6. Two mouth papillæ on each side of jaw. Four arm spines . . . 7
 One mouth papilla on each side of jaw. Three arm spines¹
O. profundæ Ltk. and Mrtsn.
O. nidarosiensis Mrtsn.
7. Dorsal plates of arms elongate-oval. Large genital slits (Fig. 111)
 Dorsal plates of arms very broad. No genital slits
O. virens (M. Sars)

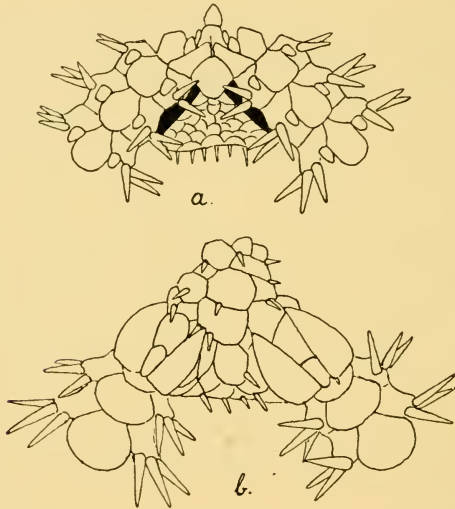


FIG. 111.—*Ophiactis nidarosiensis* ; part of oral (a) and dorsal side (b).
 × 18. (After Th. Mortensen, *Scand. Ech.*)

1. *Ophiactis Balli* (Thompson). (Fig. 112.)

(Syn. *Ophiocoma Goodsiri* Forbes.)

Disk with rather small scales, those on the oral side much finer. Generally no spines on dorsal side, but on the edge and on the ventral side. Primary plates not distinct. Radial shields small, separated by a wedge of scales. Arms 5. Dorsal plates

¹ *Ophiactis profundæ* may possibly only be a synonym of *O. plana* Lyman.

of arms triangular, contiguous, with truncated inner angle. Ventral plates rounded, farther out with somewhat concave outer edge; a very obtuse inner angle. One fairly broad tentacle scale. Five, farther out 4, rather short, conical arm spines. Mouth shields rounded triangular; a single small mouth papilla on each side of jaw. Colour in life mostly reddish on disk, often variegated with white; arms usually banded with red-brown and whitish. (The colour keeps fairly well in alcohol.) Reaches scarcely more than 5 mm. diameter of disk; length of arms ca. six times the diameter of disk.

The species is exceedingly variable in its colour, and recalls to so striking a degree, both in colour and general aspect, young

specimens of *Ophiopholis aculeata*, that it is hardly possible, without a microscopical examination, to distinguish these two in reality widely different forms, which are often found living together in the same localities. Both of them are fond of concealing themselves in small cavities in stones, shells, etc., often so small that they must squeeze their body and twist and turn their arms in order to get in. *O. Balli* is also commonly found between the membranaceous layers of Chætoperus tubes. When it contains ripe genital products the disk generally projects rather strongly between the arms.

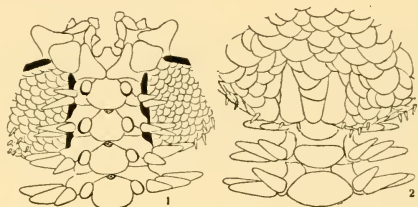


FIG. 112.—*Ophiactis Balli*. 1. Oral side. 2. Dorsal side. $\times 8$. (From *Danmark's Fauna*.)

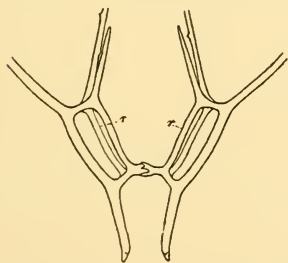


FIG. 113.—Body skeleton of the larva of *Ophiactis Balli*. $\times 275$. (From *Danmark's Fauna*.)

r. Recurrent rod.

the fully-formed larva unknown.

In British seas this species is common off the south and west coasts, and on the North Sea coasts it is known as far south as Northumberland and Durham, where it is stated (Hodge) to be very numerous in the magnesian limestone from deeper water; recorded also from the Rockall and Lousy Banks. It occurs mainly in depths of ca. 60-400 m., but has been found down

to 1765 m. It is elsewhere known along the Scandinavian coasts from the Skagerrack to the Trondhjem Fjord, and towards the south to S. of the Canaries. It is not known from Greenland or the American coasts.

2. *Ophiactis abyssicola* (M. Sars). (Fig. 114.)

(Syn. *Amphiura abyssicola* M. Sars ; *Ophiactis poa* Lyman ;
O. corallicola Koehler.)

Disk with rather coarse scales, those on the oral side much finer ; the primary plates are fairly distinct. Rather coarse spines scattered both on dorsal and oral side ; radial shields fairly large, not very broad, separated by a single row of scales. Arms 5. Dorsal plates of arms broad, fan-shaped, contiguous ; ventral plates with produced outer corners. One tentacle scale (exceptionally 2). Arm spines 4, farther out 3, rather slender. Mouth

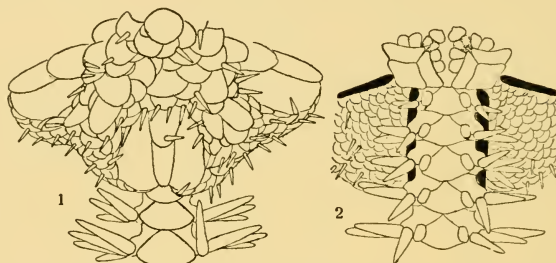


FIG. 114.—*Ophiactis abyssicola*. 1. Dorsal side. 2. Oral side. $\times 4$.
(From *Danmark's Fauna*.)

shields rhombic. Two broad, scale-like mouth papillæ on each side of jaw. Colour in life reddish, in alcohol usually bluish-grey. Grows to a size of 8-9 mm. diameter of disk. Arms ca. 6 times as long as the diameter of disk.

It occurs among corals and alcyonarians, and especially on the Bird's-nest sponge, *Pheronema*. Development unknown.

In British seas this species is one of the commonest Ophiuroids in deep water off the Irish coasts. Also found on the Lousy Bank and in the Faroe Channel ("Porcupine"). It is elsewhere distributed from Finmark to the Bay of Biscay and the Azores, and even to S. Africa. Also known from Greenland. Bathymetrical distribution ca. 125-1850 m.

Ophiactis corallicola Koehler can scarcely be maintained as a separate species. The characters by which it is to be distinguished from *abyssicola* are : the presence of spines only on the dorsal side of disk, and the emarginate edge of the disk in the interradii ;

also the radial shields are generally, but not constantly, contiguous in their distal part. Not one of these characters is constant, and as other, better characters do not seem to exist, the result seems indisputable that *O. corallicola* is only a synonym of *O. abyssicola*.

2. *Ophiopus* Ljungman.

(Syn. *Ophiaregma* G. O. Sars.)

Disk with scales only, no spines or granules. Two to three mouth papillæ on each side of jaw. Arms 5. No small plates around dorsal arm plates. Arm spines short, conical, none of them hook-shaped. No genital slits, only a small fold along each side of arm, which may be regarded as a rudimentary bursa.¹

Only one species known.

1. *Ophiopus arcticus* Ljungman. (Fig. 115.)

(Syn. *Ophiaregma abyssorum* G. O. Sars.)

Disk scales rather coarse, those of the ventral side not much smaller. Primary plates as a rule fairly distinct. Radial shields very small, separated by a wedge of scales. Dorsal arm plates elongate-triangular, with outer edge rounded; the proximal ones contiguous, with truncate inner end. Ventral plates with rounded outer edge, farther out with a slight concavity in the middle; the proximal ones contiguous. One rather large tentacle scale. Four, farther out 3, subequal arm spines. Mouth shield rounded triangular. Two large outer mouth papillæ, sometimes also a very small inner one. Colour in alcohol bluish-grey or whitish. Diameter of disk scarcely surpassing 5 mm.; arms ca. five times that length.

The eggs are extruded through small, round holes formed in the ventral side of disk, one to each ovary, not symmetrically situated. The large size of the eggs (ca. 0.4 mm.) indicates direct development, without an *Ophiopluteus* stage.

¹ *Ophiactis virens* (M. Sars) also lacks the genital slits or has only a similar fold along the arms as *Ophiopus*. While the species *O. virens* is very easily distinguished from the 5-armed *Ophiopus* by its 6-7 arms, the lack of genital slits in the said species deprives the main character of the genus *Ophiopus* of its real value. In fact the only character then remaining to distinguish *Ophiopus* from *Ophiactis* is the absence of spines on the disk in the former. It may be questionable whether *O. virens* can really remain within the genus *Ophiactis*—there are also some exceptional features in its internal structure; but this cannot be decided before the anatomy of the other *Ophiactis* species has been more carefully investigated.

In British seas this species has been found only in the Faroe Channel ($60^{\circ} 25' N.$, $8^{\circ} 10' W.$, 690 m., "Porcupine"). Else-

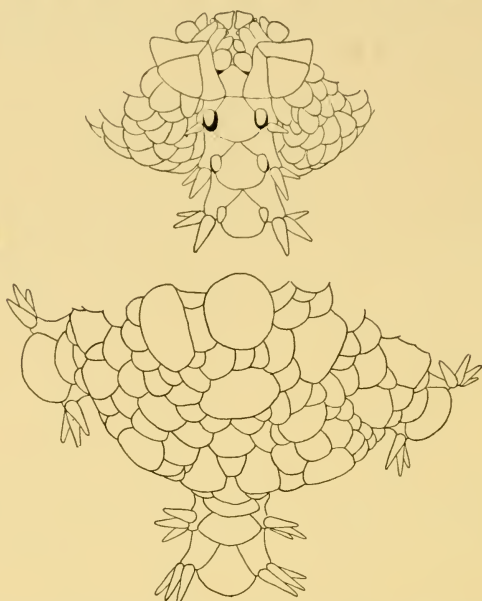


FIG. 115.—*Ophiopus arcticus*; part of oral (upper figure) and dorsal side (lower figure). $\times 15$.

where known from the Norwegian coast to Spitzbergen, Iceland, and Greenland. Bathymetrical distribution ca. 50-ca. 1200 m.

3. *Ophiopholis* Müller and Troschel.

(Syn. *Polypholis* Duncan.)

Disk with granules or spinelets which cover the scales, but generally leave the primary plates naked and very distinct. A circle of small plates surrounds the dorsal plates of the arms. The lower arm spine hook-shaped in distal part of arm. Genital slits well developed.

Only one species in the British (and European) seas.

1. *Ophiopholis aculeata* (Linn.). (Fig. 116.)

(Syn. *Ophiocoma bellis* Forbes; *Ophiopholis bellis* Lyman;
Polypholis echinata Duncan.)

Disk with granules, often with small spines scattered among them, leaving the primary plates naked; these latter generally

form a conspicuous 10-radiate star. Radial shields as a rule completely concealed. On the ventral side the granules or spinelets may be wholly wanting. Dorsal plates of arms transverse-oval, wholly separated by the surrounding small plates. Ventral plates almost rectangular, usually separated by a small depression. Six to seven short, thick, more or less compressed, outstanding arm spines. The lower one the shortest; in outer part of arm transformed into a hook with usually one small thorn below the large terminal claw. One rather large tentacle scale, exceptionally two at the proximal pores. Three, rarely two, mouth papillæ; the infradental papilla usually very small. Mouth shields oval, but rather variable in shape. Colour (which keeps

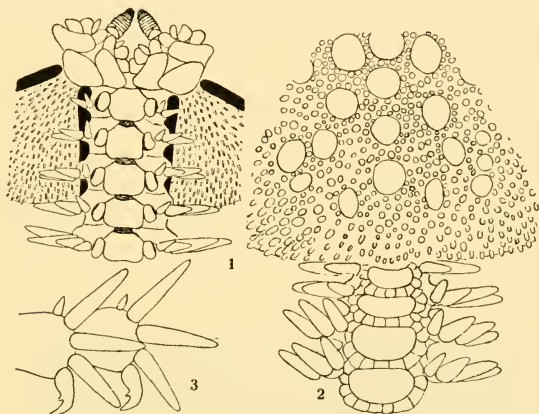


FIG. 116.—*Ophiopholis aculeata*. (From *Danmark's Fauna*.)

1. Part of oral side. 2. Of dorsal side. 3. Two arm joints from distal part of arm, in side view, showing the lower arm spine transformed into a hook. 1 and 2. $\times 4$. 3. $\times 8$.

well in alcohol) mostly red, often variegated; more rarely the disk may be bluish. Arms often dark banded. Grows to a considerable size, ca. 15-20 mm. diameter of disk. Arms ca. four times that length.

It is a robust form, with relatively short, coarse arms. Its movements are very slow. Like *Ophiothrix*, *Ophiopsila*, and *Ophiactis Balli*, it is fond of nestling in hollows and crevices of stones, shells, etc., being able to squeeze its disk and twist its arms so as to conform with the irregularities of the crevices. Its food appears to be mainly detritus. It is eaten especially by the cod.

The eggs are very small and numerous; when full of mature sexual products the interradial spaces of the disk are rather swollen and bulging out between the arms. Its larva is a typical

Ophiopluteus, with simple body skeleton (Fig. 88, 5), each transverse rod with a forwardly directed process. Postero-lateral arms of medium length. Breeding season June-July.

In British seas this species is common all round the coasts, though scarcer along the south coast; also recorded from the Rockall Bank. It seems to be rare below ca. 300 metres, but has been found at a depth of ca. 1000 m. in the Faroe Channel ("Poreupine"). It is widely distributed in the Arctic seas, circumpolar, and occurs along the Scandinavian coasts down to the Sound and the Belts; its southern limit in European seas is the British south coast. On the American side of the Atlantic it goes as far south as Cape Cod. Also in the Northern Pacific it is widely distributed, as far south as California and Japan. Bathymetrical distribution from the ebb-zone to 1880 m.

VI. Family AMPHIURIDÆ

Disk generally distinctly scaled, sometimes with spines. A pair of infradental papillæ on apex of jaw; papillæ on sides of jaw contiguous or not contiguous with the infradental papillæ. A single series of square teeth, no tooth papillæ. Two pairs of tube-feet inside the mouth edge. Arms mostly very long,

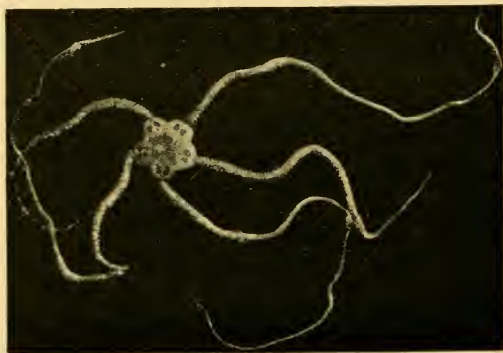


FIG. 117.—*Amphiura Chiajei*. Dorsal side. Nat. size.
(From *Danmark's Fauna*.)

slender, and very flexible. Arm spines short, outstanding. Genital organs small, not in the shape of a single large mass at each bursal slit.

Most Amphiurids are characterised by their very long and slender, very flexible arms (Fig. 117). They usually live buried about a decimeter deep in the ground, with only the tip

of the arms protruding above the ground-surface for catching the food ; this consists in the main of detritus, but also all sorts of small organisms, worms, young molluscs, and echinoderms, etc., are captured and are transferred to the mouth by means of the tube-feet. They seem to exercise but rough selection in picking out detritus or living forms of food. They may occur in very great numbers, the bottom being completely interwoven by their arms, as with a web, and they doubtless play a very important rôle in the economy of the sea ; some of the animal communities of the sea are especially characterised by Amphiurids (*e.g.* in the Moray Firth). As food for fishes they are of small importance.

Most of the species live on mud bottom ; one of the European species, *Acrocnida brachiata*, lives in sand, burying there as do the other species in the mud. Another, *Amphipholis squamata*, is very common under stones at low water. In accordance with these habits the Amphiurids do not as a rule move freely about, as do most other Ophiuroids, and when placed on a hard substratum do not push themselves forward, like other Ophiuroids, but move in this way that one arm is extended and then snake-like contracted, the outer end fastening to the substratum ; the body is thus dragged forwards, the four other arms being drawn after. When extruding the genital products they assume a very curious position (Fig. 118), raising themselves some centimetres above the bottom, the disk resting on the proximal part of the arms as on five columns ; the distal part of the arms remains in the ground. When the genital products are emptied out the animal again sinks down in the ground.

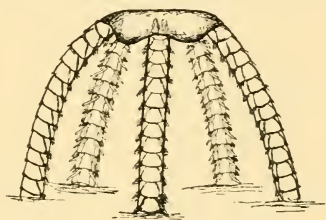


FIG. 118.—An *Amphiura* in its spawning position. (After Th. Mortensen, *Scand. Ech.*)

Several Amphiurids are viviparous and hermaphrodite, among them two British species, *Amphiura borealis* and *Amphipholis squamata*. Others have a typical Ophiopluteus larva ; the development is, however, known only for one species, *Amphiura filiformis*. Two species are known to be phosphorescent, viz. *Amphiura filiformis* and *Amphipholis squamata*.

In their general appearance the Amphiurids are very much alike, and, especially within the genus *Amphiura* proper, it is hardly possible to distinguish the species without microscopical examination. It is therefore important to collect abundant

material, especially from deeper water, in order to secure all the species present. The very numerous species within this family are divided, mainly according to the number of the mouth papillæ, into several genera, four of which are represented in British (and European) seas. Two other genera are known from off Cape Verde, viz. *Ophiostigma* Lütken, with the species *O. africanum* Lyman, and *Amphilimna* Verrill, with the species *A. (Ophiocnida) libera* (Koehler), but as both are littoral forms there is scarcely any prospect of finding them as far north as the British coasts, and no further mention of these two forms is needed here.

*Key to the genera of Amphiuridæ known from the
British (and European) seas.*

1. One outer mouth papilla on each side of jaw, not contiguous with the infradental papillæ 2
Two outer mouth papillæ on each side of jaw, contiguous with the infradental papillæ; the outermost very broad, scale-like 4. *Amphipholis* Ljungm.
2. Scales of ventral side and on margin of dorsal side of disk each ending in a small tubercle; radial shields with a transverse furrow 2. *Acrocnida* Gislén
Scales smooth; radial shields without transverse furrow 3
3. Apparently two pairs of plates between adoral plates and infradental papillæ 3. *Paramphiura* Koehler
Only one pair of plates (the jaw, generally apparently unpaired) between adoral plates and infradental papillæ 1. *Amphiura* Forbes

1. **Amphiura** Forbes.

(Syn. *Ophiopeltis* Düben and Koren.)

A single-mouth papilla (exceptionally two) on each side of jaw at the outer end of the mouth slit, widely separated from the infradental papillæ. Deeper on each side of jaw is seen a single, centrally-directed papilla, belonging to the first tube-foot (this papilla is not counted among the mouth papillæ proper). Arms very long, slender, and very flexible. Disk scales not spinous or thorny. Generally, the disk is somewhat incised above each arm.

Six species of this genus have been recorded from the British seas, but several more are more or less likely to be found there, namely: *Amphiura abyssorum* Norman (55° 10' N., 25° 58' W., 3210 m., "Valorous"; only one specimen known); *A. digna* Koehler (19° 19' N., 20° 22' W., 2320-2330 m., "Talisman"; only one specimen known); *A. grandis* Koehler (Bay of Biscay,

Azores, Canaries, Cape Verde, 1900-3200 m., "Princesse Alice", "Talisman"); *A. grandisquama* Lyman (syn. *A. longispina* Koehler) (Bay of Biscay, Azores, to Cape Verde, ca. 400-1635 m.; also known from off Florida and the W. Indies, 225-470 m.); *A. Griegi* Mrtsn. (Hardanger Fjord, Trondhjem Fjord, ca. 60-300 m.); *A. iris* Lyman (off Portugal to S. of the Canaries, 307-885 m., "Talisman"; also known from the Pacific, S. of Japan, "Challenger", and the Malay Archipelago, "Siboga"); *A. josephinae* Ljungman (Josephina Bank, 288 m., "Josefina"); *A. Otteri* Ljungman (off Portugal, 990 m., "Josefina"; Azores, 1620 m.; also known from the W. Indies, and off Cape Cod, ca. 210-1425 m.); *A. Palmeri* Lyman (42° 42' N., 11° 56' W., 521 m., "Talisman"; also known from the W. Indies, 180-470 m.); *A. Richardi* Koehler (Azores, off Portugal, 1165-1494 m., "Talisman", "Princesse Alice"); *A. Sarsi* Ljungman (Azores, Josephina Bank, ca. 200-540 m., "Josefina"). The main characters of these species are given in the key.¹ It has also been deemed advisable to include in the key *A. mediterranea* Lyman; although as yet not known to occur outside the Mediterranean, it may well be expected to occur along the Atlantic coasts some distance both to the north and the south of the Gibraltar Strait; it is known only from the littoral region.

*Key to the species of Amphiura known from or likely
to exist in the British seas.*

- | | |
|--|--------------------------|
| 1. Two tentacle scales | 2 |
| One tentacle scale | 8 |
| No tentacle scales | 10 |
| 2. Under side of disk wholly covered with scales | 3 |
| Under side of disk partly or wholly naked | 7 |
| 3. Outer mouth papilla broad, more or less leaf-shaped, not
conical | 4 |
| Outer mouth papillæ conical | 6 |
| 4. Spines not hooked | 5 |
| Second and third ventral spine with a small, distally directed
terminal hook; 6-5 spines ² | <i>A. Palmeri</i> Lyman. |
| 5. Spines 4-6, conical; primary plates of disk generally distinct | |
| 1. <i>A. Chiajei</i> Forbes | |

¹ Another species of *Amphiura* has been recorded from off the Portugal coast, 552 m., namely, *A. angularis* Lyman ("Princesse Alice"); the single specimen found was, however, only a young one, and Koehler himself later on declared the identification doubtful, so that we may leave this species out of consideration.

² The outer mouth papilla of *A. Palmeri* is described as "flattened, a little elongate, erect, somewhat narrower at its basis than its end, which

Spines 7-10, partly compressed ; primary plates not distinct

A. mediterranea Lym.

6. Spines 3-4, not curved or hooked¹

2. *A. bellis*, var. *tritonis* Hoyle

Spines 5 ; the second with a terminal hook ; radial shields small ; ventral plates beyond disk keeled¹

A. grandis Koehler

Spines 7 (6-8), the second slightly incurved ; ventral plates not keeled¹ *A. Otteri* Ljungm.

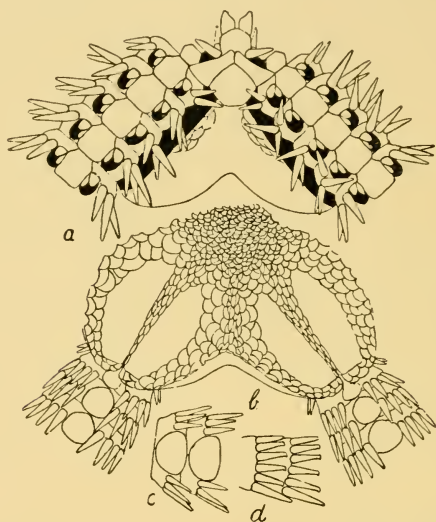


FIG. 119.—*Amphiura Griegi*; part of oral (a) and dorsal side (b); two arm-joints in dorsal (c) and side view (d). $\times 14$. (From Th. Mortensen, *Scand. Ech.*)

7. Underside of disk wholly naked ; outer mouth papilla conical, slender ; 6 arm spines (Fig. 119) . . . *A. Griegi* Mrtsn.

Underside of disk with scales near the outer edge ; outer mouth papilla conical, thick ; (4) 3 arm spines

A. Richardi Koehler

8. Lower arm spine curved, sabre shaped, much longer than the other four, equalling 2 arm-joints ; radial shields small, less

forms a rounded edge". A detailed description and figures of this species are given in Koehler's "Contribution to the study of Ophiurans of the U.S. National Museum", *Bull. U.S. Nat. Mus.* 84, 1914, p. 55, Pl. 18, 1 and 3.

¹ The species *A. bellis*, var. *tritonis*, *A. grandis* and *A. Otteri* appear to be very nearly related and not easily distinguished. For a detailed description and figures see Hoyle, "Rep. on the Ophiuroidea of the Faroe Channel, mainly coll. by H.M.S. 'Triton'", *Proc. R. Soc. Edinb.*, 1884, p. 716, Pl. VII. 1-3 ; Koehler, *Monaco*, xxxiv. p. 175, Pl. XXVII. 3-7 ; Koehler, *Bull. U.S. Nat. Mus.* 84, p. 61, Pl. 8, 5-9.

- than half the disk radius; proximal dorsal plates rounded, quadrangular; mouth shield rounded, triangular, with convex outer edge *A. grandisquama* Lym.
- Lower arm spine not curved, sabre shaped; upper and lower spine somewhat longer than the others; radial shields large, more than half the disk radius; proximal dorsal plates triangular; mouth shields triangular, somewhat heart shaped, the outer edge being more or less excavated 9
9. Arm spines 5¹ *A. josephinae* Ljungm.
 Arm spines 4¹ *A. iris* Lyman
10. Arm spines simple, 4 or 3, ventral side of disk partly scaled²
 *A. digna* Koehler
 *A. abyssorum* Norm.
- Arm spines serrate or, partly, hatchet shaped; ventral side of disk naked 11
11. Arm spines 7, with distal edge serrate, proximal edge smooth, spine often ending in a fine hook; outer mouth papilla small, conical 3. *A. denticulata* Koehler
 Arm spines partly hatchet shaped 12
12. Dorsal side of disk wholly or partly naked; outer mouth papilla small, scale-like 13
 Dorsal side of disk wholly scale-covered; outer mouth papilla conical 14
13. Dorsal side of disk wholly naked, excepting the narrow, contiguous radial shields . . . 6. *A. securigera* (Düb. and Koren)
 Dorsal side of disk naked in the interradi al spaces, scale-covered in the middle 5. *A. borealis* (G. O. Sars)
14. Ventral plates with concave outer edges and produced outer corners; broadly contiguous; disk scales of dorsal side coarse, primary plates not distinct 4. *A. filiformis* O. F. M.
 Ventral plates with rounded outer edge, outer corners not produced; narrowly contiguous; scales of dorsal side of disk fine, primary plates fairly distinct . . . *A. Sarsi* Ljungm.

¹ It seems very difficult to distinguish the species *iris* and *josephinae*; the difference in the number of arm spines being scarcely constant enough for separating the two forms. In any case, it would seem very probable that the Atlantic specimens referred to *A. iris* are really *A. josephinae*; whether the Pacific form may deserve being recognised as a separate species, different from *A. josephinae*, is a question that requires further study; but this does not concern us here.

² *Amphiura abyssorum* is insufficiently known (has never been figured), and it is therefore impossible to indicate how it may be distinguished from *A. digna*; the character of the ventral side of the disk is unknown (cf. *Proc. R. Soc. London*, vol. 25, 1876, p. 215).

1. *Amphiura Chiajei* Forbes. (Figs. 117, 120, 1, 2.)

Disk covered with fine scales on both dorsal and ventral sides ; those of the dorsal side diminishing gradually in size towards the edge of disk. Primary plates generally distinct ; radial shields wholly separated. Dorsal plates of arms rather fan-shaped, with fairly sharp outer corners. Ventral plates hexagonal, with outer edge slightly excavated ; the proximal ones have a more or less

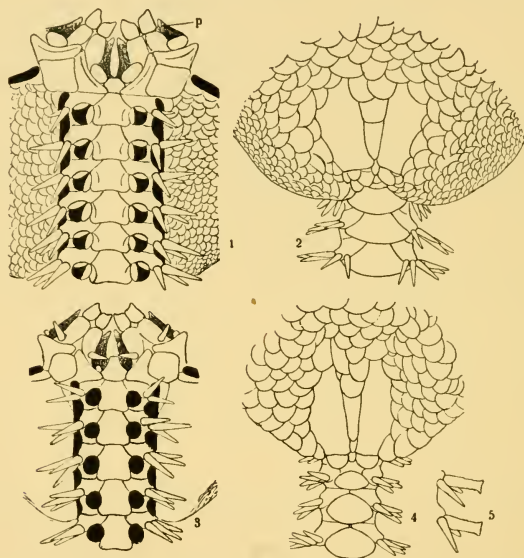


FIG. 120.—1-2. *Amphiura Chiajei*; part of oral side (1) and dorsal side (2). 3-5. *Amphiura filiformis*; part of oral side (3) and dorsal side (4); arm spines (5). All figures $\times 8$. (From *Danmark's Fauna*.)

distinct keel along the side edges ; 4-6 short, conical arm spines, not hooked or widened at the point. Two broad, scale-like tentacle scales set nearly at a right angle to each other. Mouth shields rhombic ; adoral plates meeting within, in larger specimens with a longitudinal keel. Outer mouth papilla broad, scale-like. Colour in life reddish or greyish-brown, often somewhat mottled. Reaches a size of ca. 10-11 mm. diameter of disk. Length of arms ca. 8 times the diameter of disk.

Development unknown, but it seems fairly certain that it has a typical Ophiopluteus larva. Perhaps *Ophiopluteus dubius* (Fig. 87, 4) may belong to this species ; or perhaps the larva

resembles that of *Amphiura filiformis* so much that it cannot be distinguished with certainty? Its breeding season would appear to be in the fall of the year.

In British seas this species has been recorded from various places round the south, west, north, and east coast, from Plymouth and Cape Clear to off Dogger Bank; also from the Lousy Bank; in places, at least, common; the depths recorded are 9-ca. 1000 m. It is elsewhere distributed from the Trondhjemfjord to the Sound in Scandinavian seas, and along the European coasts south to the Mediterranean, the west coast of N. Africa, and the Azores. It does not occur at the N. American coasts. Bathymetrical distribution, ca. 10-1200 m.

2. *Amphiura bellis* Lyman, var. *tritonis* Hoyle.¹

Disk covered on both sides with small scales, coarser and radially elongated near the radial shields, which are wedge-shaped, about four times as long as wide, separated by one or two series of elongate scales. Dorsal arm plates transversely oval, but with a proximal angle. Ventral plates with outer edge rounded. Three, or at the base of arm 4, straight, tapering, bluntly-pointed arm spines. Two broad, scale-like tentacle scales, set at a right angle to each other. Mouth shields rounded triangular, with a conspicuous outer lobe. Adoral shields triangular, not joining adorally to the mouth shield. Outer mouth papilla conical ("diamond-shaped"). Colour yellowish-grey, with five rather indefinite radial markings on dorsal surface of disk. Diameter of disk 12 mm., arms ca. nine times that length.

Only a single specimen known, dredged by the "Triton" at 59° 40' N., 7° 21' W., ca. 930 m.

The typical *Amphiura bellis* Lyman, originally known from off Fiji and Japan ("Challenger"), has been found off the coast of Portugal, 627-1290 m. ("Talisman").

¹ A figure of part of the ventral side of disk of this Amphiurid was given by Hoyle in *Proc. R. Soc. Edinb.* xii. Pl. VII. 1. The figure not being very satisfactory, it has been thought better not to reproduce it here. In the description (p. 716) it is not mentioned whether the primary disk plates are distinct or not. Koehler (1895), and more recently H. L. Clark, regard this form as a separate species, and refer it to the genus *Paramphiura*. The present author cannot agree with Koehler and Clark in this view, but must regard it as a typical *Amphiura*. Whether it may perhaps represent a separate species cannot be decided until more material is at hand; but it really seems very close to *A. bellis* Lyman, if not simply identical with that species.

3. *Amphiura denticulata* Koehler. (Fig. 121.)

Disk covered with scales only on the dorsal side, the ventral side completely naked; primary plates not distinguishable. Radial shields separated by a wedge of scales, sometimes contiguous at the distal end. Dorsal plates of arms rounded. Ventral plates pentagonal, with slightly concave outer edge. Five to seven arm spines; the lowermost and uppermost smooth, conical, the others slightly flattened, with distal edge serrate, proximal edge smooth; often there is a small terminal hook. No tentacle scale. Mouth shields with a small, rounded outer lobe; outer mouth papilla small, conical. Colour in life unknown. Diameter of disk up to 5 m.; length of arms ca. 10 times the diameter of disk.

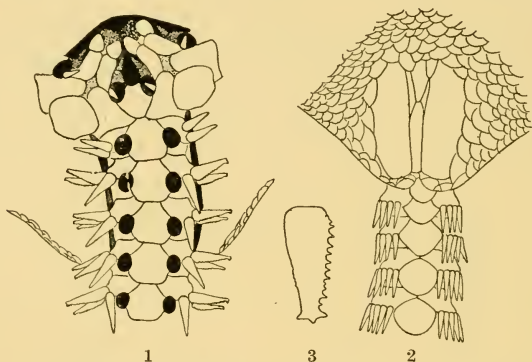


FIG. 121.—*Amphiura denticulata*; part of oral (1) and dorsal side (2); arm spine (3). $\times 15$.

In British seas this species has been found in the Faroe Channel ($61^{\circ} 07' N.$, $9^{\circ} 33' W.$, 750 m., "Michael Sars"). Elsewhere known only from Greenland to Newfoundland. Bathymetrical distribution 155-1100 m.

4. *Amphiura filiformis* (O. F. Müller). (Fig. 120, 3-5.)

Disk covered with scales on dorsal side only, ventral side naked; scales rather coarse, primary plates not distinguishable. Radial shields separate. Dorsal arm plates transverse oval; ventral plates with concave outer edge and somewhat produced outer corners; the proximal ventral plates may have a more or less distinct median keel. Five to seven arm spines, the second from below with the point axe-shaped widened (Fig. 120, 5). No

tentacle scales. Mouth shields rounded pentagonal. Outer mouth papilla conical, slender. Colour in life reddish- or greyish-brown. Diameter of disk up to 8-10 mm.; arms ca. ten times as long as diameter of disk.

It is a more delicate species than *A. Chiajei*, with which it is often found associated. On account of the delicacy of the naked skin of the ventral side, the whole disk, with the stomach and genital organs, is very easily lost, especially by the rough handling in a dredge or trawl. Such injury, however, does not kill the animal, the lost parts being easily regenerated when it is left undisturbed. This, no doubt, holds good with all the Amphiuroids with a naked ventral skin, and also some others, e.g. *Amphipholis squamata*. Like the latter species, *A. filiformis* is phosphorescent.

The larva (*Ophiopluteus mancus*) (Fig. 88, 3) is characterised by lacking the postero-dorsal arms; a recurrent rod is merely indicated. Postero-lateral arms long, with a conspicuous red spot at the end. It is found throughout the summer, at least till October.

A. filiformis is eaten by fishes, especially by haddock,¹ plaice, and dab; it is also devoured by various Asteroids and has been found in the stomach of the burrowing crab *Corystes*.

In British seas this species appears to be common inside the 100 m. line all round the coasts, at least from off Plymouth round north to Northumberland and the Dogger Bank on the east coast. It is elsewhere distributed from the Trondhjemfjord to the Sound in Scandinavian seas, and to the Mediterranean. It does not occur at the Atlantic coasts of N. America or at Greenland. Bathymetrical distribution ca. 5-ca. 1200 m.

5. *Amphiura borealis* (G. O. Sars). (Fig. 122, a-c.)

(Syn. *Ophiopeltis borealis* G. O. Sars.)

Dorsal side of disk only partly covered with scales, the inter-radii being naked, as is also the ventral side of the disk. Primary plates not distinguishable. Radial shields contiguous in their distal part. Dorsal arm plates rounded, with an obtuse angle

¹ The curious fact has been recorded by V. Franz ("Über die Ernährungsweise einiger Nordseefische", *Wiss. Ergebn. N.F.* 9, *Helgoland*, 1910) that plaice living in localities rich in *Amphiura filiformis* feed extensively on the latter, especially during night time, while otherwise the plaice is in the main a day-feeding species. It appears that it is the phosphorescence of *Amph. filiformis* that attracts the plaice to the brittle-star, to whom this property is thus rather harmful.

proximally. Ventral plates pentagonal, with scarcely excavated outer edge. Four, farther out 3, arm spines, the second from below axe-shaped widened at the point (Fig. 122, c). No tentacle scales. Mouth shield rounded triangular. Outer mouth papilla very small, scale-like; sometimes there are 2 or 3 outer mouth papillae in place of 1. Colour in life reddish-blue or bluish-black on disk, the arms flesh-coloured. Diameter of disk scarcely more than 5-6 mm.; length of arms only six to seven times the diameter of disk.

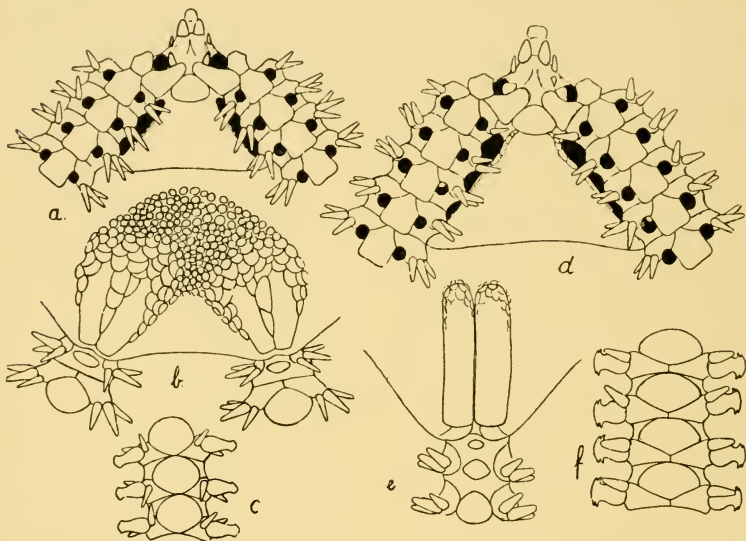


FIG. 122.—a-c, *Amphiura borealis*; part of oral side (a) and dorsal side (b), three arm-joints, seen from the dorsal side (c). d-f, *Amphiura securigera*; part of oral side (d); part of disk, with radial shields and proximal part of arm (e); four arm-joints, seen from the dorsal side (f). All figures $\times 12$. (From Th. Mortensen, *Scand. Ech.*)

This species is a proterandric hermaphrodite. It may be found on a dead coral bottom, which fact perhaps indicates that it does not live buried in the ground as do the other *Amphiuras*.

From British seas this species has been recorded only from the Faroe Channel ($60^{\circ} 39' N.$, $3^{\circ} 9' W.$, 365 m., "Porcupine"). It is elsewhere known only from the Scandinavian coasts, from Tromsø to Skagerrack. Bathymetrical distribution ca. 150-800 m.

6. *Amphiura securigera* (Düben and Koren). (Fig. 122, *d-f*.)

(Syn. *Ophiopeltis securigera* Düb. and Koren ; *Amphiodia securigera* (Düb. and Koren).)

Disk completely naked, both on dorsal and ventral side, with the sole exception of the radial shields, which are narrow, parallel, and contiguous in their whole length (Fig. 122, *e*). Dorsal arm plates fan-shaped, with convex outer edge and an obtuse angle within, well separated, the proximal ones rudimentary ; ventral plates pentagonal, with straight outer edge. Three, in the proximal part of arm 4, arm spines, the second from below strongly axe-shaped widened at the point. No tentacle scales, or, at most, a single small scale here and there at a pore in the distal part of arms. Mouth shields rounded triangular. Outer mouth papilla small, more or less pointed ; often two small papillæ are found here. Colour in life olive-green or brownish-green on disk, the radial shields whitish ; arms dark brownish, in the proximal part somewhat lighter coloured. Diameter of disk scarcely exceeding ca. 5 mm. Arms very long, twelve to fifteen times the diameter of disk, usually very strongly coiled up.

Development unknown. It appears that this species prefers a hard bottom, and conceals itself among shells or the like.

In British seas this species has been found off Shetland, 70-90 m. (Norman), 61° 10' N., 5° 46' W., 290 m. ("Michael Sars") ; also the "Porcupine" found it in the Faroe Channel. It has further been found off Eddystone, ca. 50 m. (the author). It is elsewhere known only from the Norwegian coast, as far north as Lofoten, and from the Faroes. Bathymetrical distribution ca. 40-600 m.

2. *Acrocnida* Gislén.

Scales of ventral side of disk and at margin of dorsal side produced into a small tubercle, giving a slightly spinous appearance ; no real spines on disk. Radial shields with a transverse furrow near the distal margin.¹ Ventral plates of arms longitudinally furrowed.

One species known from the British seas ; another species, *A. neapolitana* (M. Sars), occurs in the Mediterranean, and a third species, *A. semisquamata* (Koehler), on the West African coast.

¹ In Fig. 123 this transverse furrow on the radial shields has inadvertently been omitted.

Both being littoral forms there is scarcely any prospect of finding any of them within the British area. *A. neapolitana* is distinguished from *A. brachiata* by having granulated radial shields, *semisquamata* by having only 6 arm spines, 1 tentacle scale and ventral side of disk naked.

1. *Acrocynida brachiata* (Montagu). (Fig. 123.)

(Syn. *Amphiura*, *Ophiocnida*, *Amphiocnida brachiata* (Mont.);
Ophiocentrus brachiatus (Mont).)

Disk covered with scales on both sides. Primary plates inconspicuous; radial shields small, smooth, separated. Dorsal arm plates very short, nearly rhombic; ventral plates short and

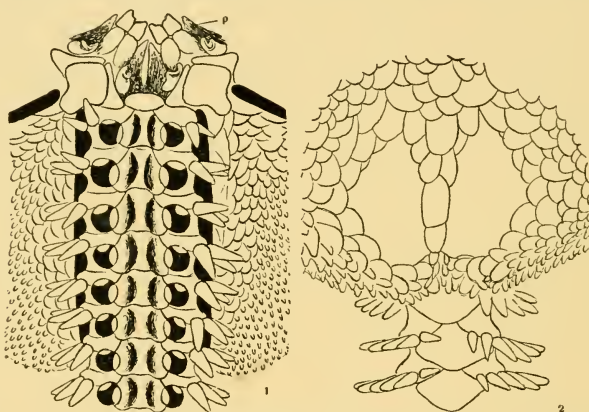


FIG. 123.—*Acrocynida brachiata*; part of oral side (1) and of dorsal side (2).
× 9. (From *Danmark's Fauna*.)

broad, nearly rectangular, with sinuate excavated outer edge. In the proximal part of arm they have a sharp median keel and a pair of lateral keels; these keels gradually disappear farther out on the arm, the median keel being visible for a longer distance than the lateral keels. Eight to ten (or even as many as 12-13) short arm spines in proximal part of arms. Two tentacle scales in the proximal part; some distance beyond the disk the inner (adradial) papilla disappears, while the outer one continues to about the middle of the arm, diminishing in size. In the distal half of arms there are no tentacle scales. Mouth shields spear-head-shaped, with a conspicuous outer lobe. Outer mouth papilla broad, scale-like, somewhat folded. Colour in life bluish- or brownish-grey. Diameter of disk up to ca. 12-13 mm.; arms ca. fifteen times that length.

Lives on sandy bottom, buried about a decimetre deep in the sand, with the point of the arms just protruding above the ground surface. Development unknown. Commensal with this brittle star are found the mussel *Montacuta bidentata* and the Polynoid *Harmothoë lunulata*, in its young stages ; larger specimens of this worm are found living on *Synapta* or on other Polychæte worms.

In British seas this species has been found at the south coast (especially common in the Salcombe Estuary, where it may be dug out at very low tide), Clare Island, coast of Down and Antrim, Kenmare River, Tenby, Firth of Forth, and the Clyde. May well be supposed to occur all round the coasts in suitable localities. It is elsewhere known only from the west coast of Sweden, the Danish North Sea coasts, and further along the French coasts. (The Mediterranean form is maintained by Gislén as a separate species, *A. neapolitana* (M. Sars).) It is not known from greater depths than 40 m.

3. *Paramphiura* Koehler.

Differs from *Amphiura* in the outer mouth papilla being developed into a large rounded scale, which covers most of the jaw, almost joining its neighbour in the mid-line, and assuming the aspect of an extra plate so that there are apparently two pairs of plates between the infradental papillæ and the adoral plates.

Only one species known.¹

1. *Paramphiura punctata* (Forbes). (Fig. 124.)

(Syn. *Ophiocoma punctata* Forbes.)

Both sides of disk covered with fine scales. Primary plates not distinguishable. Radial shields very narrow, linear, parallel, wholly separate. Dorsal arm plates elongate, rounded ; ventral plates elongate, nearly rectangular, with somewhat excavated outer edge ; 5 slender arm spines ; 2 small tentacle scales.

¹ Koehler, to whom we are indebted for the description and figures of this form (the original description by Forbes being quite unsatisfactory), regards *Amphiura tritonis* Hoyle as belonging to the present genus, and is followed herein by H. L. Clark. The present author cannot agree with this view, but must regard the form described by Hoyle as a typical *Amphiura* (cf. p. 213). The interpretation of the extra plates on the jaw as representing the outer mouth papillæ would seem to be correct. But it would be very desirable to have this interesting form made the object of a renewed study.

Mouth shields rounded triangular, with the apex directed outwards. Colour in life unknown. Diameter of disk 3 mm., arms five times that length.

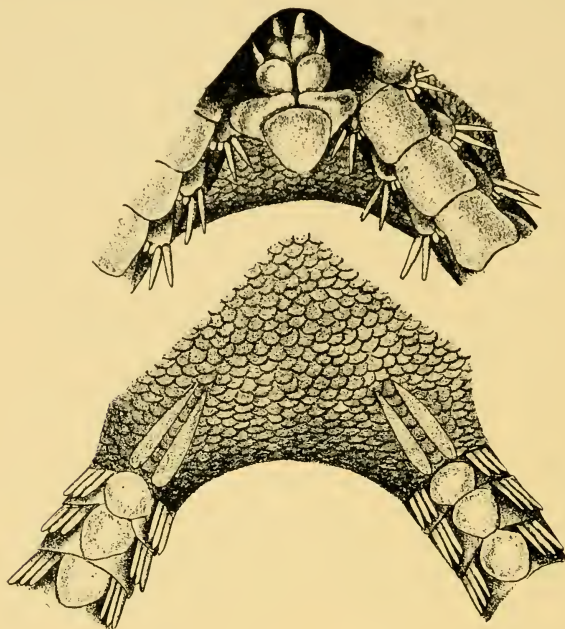


FIG. 124.—*Paramphiura punctata*; part of oral and dorsal side. $\times 20$.
(After Koehler, *Notes échinologiques*.)

Only two specimens are known. The type specimen of Forbes was found in the stomach of a cod, probably from the Dogger Bank. The second specimen was found in the Channel (Giard).

4. *Amphipholis* Ljungman.

Differs from *Amphiura* in having two outer mouth papillæ, contiguous with the infradental papillæ. The outermost papilla is very broad, scale-like, and may, together with that of the opposite side, cover the outer part of the mouth slit completely. Radial shields usually contiguous. Arms usually rather short.

Only one species known from the British seas, but at least one more, *A. Torelli* Ljungman (known from Iceland and Greenland, the littoral region), is very likely to occur there also, especially in the northern parts of the British area. A third species, *A. instructa* Koehler (a single specimen found at the

Cape Verdes, 75-80 m. "Talisman"), is scarcely likely to occur so far north as the British region. It is very easily distinguished from *A. squamata* by having spines on the disk.

Key to the species of Amphipholis known from or likely to occur in the British seas.

Arms 5	.	.	.	.	.	.	1. <i>A. squamata</i> (D. Ch.)
Arms 6	.	.	.	.	.	.	<i>A. Torelli</i> Ljungm.

1. *Amphipholis squamata* (D. Chiaje). (Fig. 125.)

(Syn. *Amphiura squamata* (D. Ch.); *Amphiura*, *Amphipholis elegans* (Leach); *Amphiura neglecta* (Johnston); *Amphipholis tenera* Lütken; *A. lineata* Ljungman.)

Disk covered on both sides by rather small scales, among which the primary plates are scarcely distinguishable. Near the edge usually a sharp limit between the scales of the dorsal and ventral side. Radial shields small, ca. $\frac{1}{3}$ of the disk radius, contiguous throughout their whole length. Dorsal arm plates in

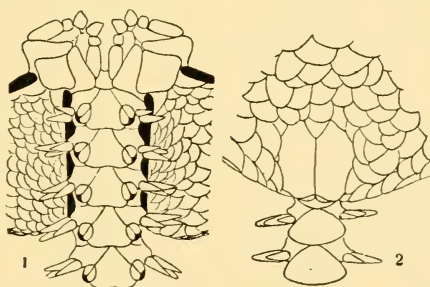


FIG. 125.—*Amphipholis squamata*; part of oral side (1) and of dorsal side (2). $\times 12$. (From *Danmark's Fauna*.)

the proximal part of arms broader than long, rounded triangular; ventral plates with slightly excavate outer edge, contiguous in proximal part of arm. Four, farther out 3, short, conical arm spines. Two tentacle scales, in distal part of arms only 1. Mouth shields about rhombic, but somewhat produced inwards. Outer mouth papilla very broad. Colour in life greyish-white or bluish-grey. Reaches only a size of ca. 5 mm. diameter of disk; arms ca. four times that length.

The variety *tenuispina* Ljungman differs from the typical form in having somewhat coarser scales on the dorsal side, there being only 4 scales in a transverse row between two adjoining pairs of radial shields, while in the typical form there are ca. 8 scales in a transverse row. The primary plates are more distinct,

also the radial shields are slightly larger, ca. half the disk radius, and the arm spines a little longer and more slender than in the typical form. There are, however, all transitional stages, so that this form can hardly be maintained as a distinct variety, still less as a distinct species, as is done by several authors.

This species is viviparous and hermaphrodite; it is phosphorescent. It is liable to lose its disk on rough handling (*e.g.* in the dredge). It occurs on a sandy or stony bottom, especially under stones between tide-marks, also among the roots of algæ, especially *Corallina*. A Copepod, *Cancerilla tubulata* Dalyell (of the family Astrocheridæ), is not rarely found as a parasite on this Ophiuroid, usually attached to the ventral side of an arm, near the mouth. In the bursæ another, very much reduced, parasitic Copepod, *Philichthys amphieuræ* Hérouard, occurs, and, finally, the remarkable *Rhopalura Giardii* Metschnikoff, of the family Orthonectidæ, lives in the body cavity of this Ophiuroid.

In British seas this species is common round all the coasts. It is of cosmopolitan distribution, in temperate and warm seas. The bathymetrical distribution is from the tide-marks down to ca. 250 m. The variety *longispina* would appear to belong more to the deeper water than does the typical form, down to ca. 480 m.

VII. Family AMPHILEPIDÆ¹

In general aspect very like the Amphiuroids, but distinguished by having a single, unpaired infradental papilla, and by the second tube-foot being wholly outside the mouth edge.

Only one genus in British and European seas.²

1. *Amphilepis* Ljungman.

Disk very flat, covered with naked scales. Mouth papillæ in a continuous series. No bursæ;³ a small spot between the large genital plates, covered over with thin skin, probably serves for the passage of the genital products. Arms very long and slender.

Only one species known from British and European seas.

1. *Amphilepis norvegica* Ljungman. (Fig. 126.)

Disk covered on both sides with fine scales, among which the primary plates are distinct. Radial shields large, triangular,

¹ Perhaps more correctly "*Amphilepididæ*".

² The genus *Amphiactis* Matsumoto, usually referred to this family, in the opinion of the present author, belongs to the Ophiactidæ (cf. p. 198).

³ It is unknown whether this holds good for all the species of this genus.

contiguous at their outer end, diverging inwards. Dorsal arm plates nearly transverse oval, well separated; ventral plates pentagonal, with slightly excavated outer edge, well separated. Three slender arm spines; no tentacle scales. Mouth shield triangular-rounded; two mouth papillæ on each side of jaw, the outer one very broad, scale-like. Colour in life bluish- or brownish-grey on centre of disk, the edge and the arms generally light yellowish. Reaches a size of ca. 7 mm. diameter of disk; arms ten to twelve times as long as diameter of disk.

It lives on mud bottom, probably buried in the mud in the

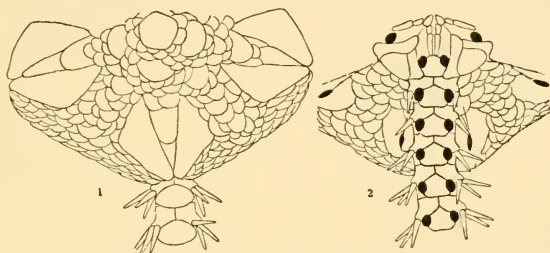


FIG. 126.—*Amphilepis norvegica*. Part of dorsal side (1) and oral side (2).
× 8. (From *Danmark's Fauna*.)

same way as the *Amphiurus*. Otherwise nothing known of its biology or development. A species of *Loxosoma* is not rarely found attached to its oral side.

In British seas this species has been found off S.W. Ireland, ca. 940-1765 m. ("Helga"); further, it was taken at various stations in the Faroe Channel by "Michael Sars". It is elsewhere distributed from Lofoten to Skagerrack on the Scandinavian coasts, and towards the south to the Bay of Biscay and S. of the Canaries; also in the Mediterranean. It is also known from the east coast of North America, but not from Greenland. Bathymetrical distribution ca. 100-2900 m.

VIII. Family OPHIOCHITONIDÆ

Disk usually with very small naked scales. A number of mouth papillæ contiguous with the infradental papilla, which may be single, well developed, or apparently double, rudimentary. A single series of teeth; no tooth papillæ. Second pair of tube-feet inside the mouth edge. Tentacle scales large, leaf-like. Arms rather stout; arm spines slender, more or less distinctly erect.

Only one genus of this family known from the British seas.

Another, *Ophionereis* Lütken, is represented in European seas by the species *O. reticulata* Lütken, which has been found at the Azores (also at the Cape Verde Islands), at depths of 225-500 m. There is scarcely any prospect of this mainly littoral West Indian species occurring as far north as the British coasts. (The genus *Ophionereis* is very easily recognised by having a supplementary plate on each side of the dorsal arm plates.)

1. *Ophiochiton* Lyman.

Dorsal side of disk usually with a series of larger marginal scales. Dorsal arm plates without supplementary plates. Arms usually with a keel along ventral and dorsal mid-line. A well-developed infradental papilla, the outermost mouth papillæ enlarged.

Only one species known from the British seas, but another, *Ophiochiton solutus* Koehler, has been found off the Azores and Madeira, 1139-2220 m. ("Talisman"), and may thus well be expected to occur also in the deep sea off the British coasts.

Key to the species of Ophiochiton known from or likely to occur in the British seas.

- Mouth shield broader than long, triangular, with a small outer lobe ;
no keel along dorsal side of arms *O. solutus* Koehler ¹
Mouth shield not longer than broad, somewhat spearhead-shaped,
with a more or less conspicuous outer lobe ; an indistinct keel
along dorsal side of arms 1. *O. ternispinus* Lyman

1. *Ophiochiton ternispinus* Lyman. (Fig. 127.)

(Syn. *Ophiochiton tenuispinus* Lyman.)

Primary plates and several other, somewhat minor, plates very conspicuous in the general small scaling on the dorsal side of disk. Radial shields small, wholly separated. Dorsal arm plates very broad, with slightly convex outer edge, broadly contiguous, somewhat elevated in the middle towards the outer edge, which produces a slightly keeled aspect ; ventral plates likewise broadly contiguous, with somewhat produced outer corners and convex outer edge. A rather distinct keel along ventral mid-line of arm. Three arm spines, the upper one the longest. Two tentacle scales, the outer one the larger, and more or less com-

¹ The difference between *O. solutus* and *ternispinus* is so inconsiderable that it would seem rather probable that *O. solutus* is really identical with *ternispinus*.

pletely covering the inner one, so that there is apparently only one scale. Mouth shields about as long as broad, with a more or less conspicuous outer lobe. Adoral shields narrow, meeting

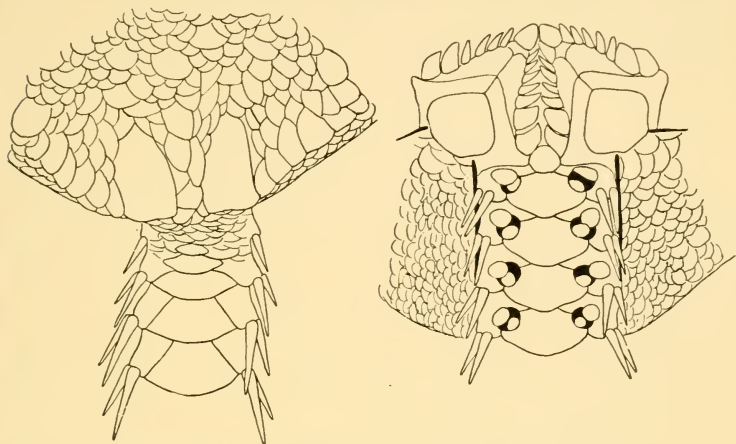


FIG. 127.—*Ophiochiton ternispinus*; part of dorsal and oral side. $\times 5$.

inside the mouth shield. Five to six mouth papillæ. Colour in life unknown; in alcohol brownish-grey or whitish.

Only three specimens of this species are known at present. One was taken by the "Porcupine" S.W. of Ireland ($49^{\circ} 12' N.$, $12^{\circ} 52' W.$, 1577 m.), another by "Michael Sars" at $57^{\circ} 41' N.$, $11^{\circ} 48' W.$, 1853 m., and a third in the Davis Strait, 442 m. (Wandel).

[Family OPHIODERMATIDÆ]

A close granulation as a rule conceals completely the fine scales of both dorsal and oral side of disk; even the jaws are mostly covered with granules, while the radial shields and the mouth shields may be naked. Mouth papillæ numerous, forming a continuous series. A single series of teeth; no tooth papillæ. Arm spines appressed. Second tube-foot inside the mouth edge.

No representatives of this family are yet known from the British seas, but four (five) genera are found in European seas, all of these being more or less likely to occur also in the British seas.

Key to the genera of Ophiodermatidæ likely to be represented in the British seas.

1. Two pairs of genital slits in each interradiar space

Ophioderma Müll. and Trosch.

- Only one pair of genital slits in each interradiar space

2

2. Arm spines fairly long, not strongly appressed. Teeth rounded, with hyaline edge *Ophiokonis* Lütken
 Arm spines very short, strongly appressed. Teeth small conical, of the same shape as the mouth papillæ 3
3. Mouth shields covered with granules *Cryptopelta* H. L. Clark
 Mouth shields naked *Bathypectinura* H. L. Clark

Ophioderma Müller and Troschel.

(Syn. *Ophiura* Lyman, *non* Lamarck.)

This genus, so very easily recognised by its double genital slits, is represented in European seas by only one species, *O. longicauda* (Retzius). It is known as far north as La Rochelle on the French coasts; it is common in the Mediterranean, and occurs along the African coasts as far south as Senegal, and also at Madeira and the Azores. It is a large, robust form, attaining a size of ca. 25 mm. diameter of disk, with the arms ca. 100-150 mm. long, of rather strictly littoral habits, probably not descending beyond ca. 70 metres.

Cryptopelta H. L. Clark.

Only one species of this genus known from European seas, viz. *Cr. brevispina* (Ludwig) (Syn. *Ophiokonis brevispina* Ludwig). Till recently only a single specimen was known, found off Naples (depth unknown); another specimen has now been taken off the N.W. coast of Morocco, 145 m. It will doubtless prove to be more widely distributed in the eastern Atlantic. It is a small form, easily recognised through the whole underside of disk, together with jaws and mouth shields, being covered with granules.

Bathypectinura H. L. Clark.

Only one species, *B. elata* (Koehler) (Syn. *Pectinura elata* Koehler), known from European seas. It has been found at 25° 2' N., 19° 11' W., 2325-2518 m. ("Talisman"); 34° 59' N., 33° 1' W., 2615-2865 m., and 35° 46' N., 8° 16' W., 2055 m. ("Michael Sars"), and may well be expected to occur also in the deep water off the British coasts. It is a large form, attaining a size of ca. 30 mm. diameter of test, with a length of arms of ca. 100 mm. Besides the naked radial shields and mouth shield it usually has some other naked plates near the edge of the dorsal side and on the under side of the disk. A characteristic feature is the large size of the first pair of tentacle scales.

The genus *Pectinura* Forbes is also represented in European

seas, the species *P. vestita* Forbes having been found in the Mediterranean (Ægean Sea, 160 m.). The only specimen known was found in the year 1843. Another genus, *Ophiarachnella* Ljungman, is known from off the Cape Verde Islands; the species *O. semicincta* (Studer) (Syn. *Pectinura semicincta* Studer) having been found there in 68-105 m. ("Gazelle", "Talisman"). Whether any of these will be found in the British seas is hard to say, but it would not seem very probable. Both are distinguished from *Bathypectinura* by having 2 tentacle scales, at least, in proximal part of arm. *Ophiarachnella* has naked radial shields, while in *Pectinura* these are covered by the general granulation.

Ophioconis Lütken.

Only one species, *O. Forbesi* (Heller) (Syn. *Pectinura Forbesi* Heller), known from European seas. It has been found in the Bay of Biscay (47° 48' N., 7° 46' W., 196 m., "Huxley"), at the Azores, at the Moroccan coast, and in the Mediterranean. Bathymetrical distribution ca. 20-200 m. Another species, *O. vivipara* Mrtsn., has been found off Cape Blanc, on the Senegal coast, at a depth of 20-30 m. It is not probable that this latter species will occur in the British seas. The two species are thus distinguished:

Arm spines 7, as long as an arm-joint *O. Forbesi* (Heller)

Arm spines 6-5, scarcely half as long as an arm-joint

O. vivipara Mrtsn.

The genus *Ophioconis* is by H. L. Clark referred to the family Ophiacanthidæ; though this seems unacceptable, it must be agreed that its position within the family Ophiodermatidæ is not beyond doubt.

[Family OPHIOLEUCIDÆ]

Dorsal side of disk more or less closely covered with granules, which, however, leave at least the large, rounded radial shields naked.¹ Ventral side of disk without granules or, when granules are found, the scales remain distinct. Jaws not set with granules. Mouth papillæ numerous, forming a continuous series. A single series of teeth, no tooth papillæ. Arm spines appressed, few and small. Second tentacle pore opening into the mouth slit, visible from the outside or not. Very slender and fragile deep-sea forms.

¹ This character applies to the N.E. Atlantic forms, not to the whole of the family.

Two genera are represented in the N.E. Atlantic, namely : *Ophiernus* Lyman, with the species *O. adspersus* Lym., found at 20° 38' N., 20° 40' W., 1160-1230 m. ("Talisman"), and *O. abyssalis* Koehler, found off the Azores, Madeira, and the north-west coast of Spain, ca. 1670-1970 m. ("Princesse Alice");¹ *Ophiocrates* Koehler, with the species *O. secundus* Koehler, found south of the Canaries, 2325-2638 m. ("Talisman"). The two genera are thus distinguished :

Second tentacle pore visible from the outside ; tentacle scales 2-3,
only partly concealing the large pores . *Ophiernus* Lym.
Second tentacle scale not visible from the outside ; one tentacle
scale, which wholly conceals the pore . *Ophiocrates* Koehler

The two species of *Ophiernus* are thus distinguished :

Ventral plates only half as wide as the lateral plates *O. adspersus* Lym.
Ventral plates not narrower than the lateral plates *O. abyssalis* Koehler

IX. Family OPHIOLEPIDÆ.²

Disk covered on both sides with scales, which are usually naked, rarely more or less concealed by the skin. Mouth papillæ forming a continuous series ; a single series of teeth, no tooth papillæ. Second tube-foot inside or outside the mouth edge. Arm spines appressed, mostly small and more or less rudimentary. Arms usually rather short, often with combs of papillæ at the base.

Four genera of this large family are known from the British seas, but seven more genera are likely to be represented there also, namely : *Amphiophiura* Matsumoto, with four species (see below, p. 230) ; *Aspidophiura* Matsumoto, with the species *A. minuta* (Lyman) (Syn. *Ophioglypha minuta* Lyman), one specimen taken in the Bay of Biscay, 1710 m. ("Caudan"), this species being otherwise known from off Crozet Island and south of Australia, 2415-3240 m. ; *Homalophiura* H. L. Clark, with two species (cf. p. 231) ; *Ophiomisidium* Koehler, with the species *O. pulchellum* (Wyv. Thomson) (Syn. *Ophiomusium pulchellum* Wyv. Thoms.), taken off Portugal and south of the Canaries, 946-1916 m.

¹ In the "*Challenger*" *Ophiuroidea* Lyman records another species, *Ophiernus vallincola* Lym., from off the Azores (1800 m.). It is highly probable, as pointed out by Koehler, that Lyman in reality had the species later on described by Koehler as *O. abyssalis* before him, but failed to recognise it as different from the nearly related *O. vallincola*, which occurs in the Antarctic Sea.

² Perhaps more correctly "*Ophiolepididæ*".

("Talisman"), 25° 49' N., 20° 12' W., 3015 m. ("Challenger"), also known from the S. Atlantic and off Cape of Good Hope, 270-630 m.; *Ophiophycis* Koehler, with the species *O. mirabilis* Koehler, found off the Azores, 1165 m. ("Princesse Alice"); *Ophiotypa* Koehler, with the species *O. simplex* Koehler, taken at 42° 19' N., 22° 36' W., 4000 m. ("Talisman"), and S.W. of the Cape Verde Islands, 3655-4360 m. ("Talisman", "Princesse Alice"), elsewhere known from the Bay of Bengal, 3595 m. ("Investigator"); *Ophiozonella* Matsumoto, with two species (cf. below, p. 232).

In the following key the main characters of these genera are given:

Key to the genera of Ophiolepidæ known from or likely to be represented in the British seas.

1. Second tentacle pore ¹ outside the mouth edge, sometimes opening into the mouth slit, but always distinctly visible from the outside 2
- Second tentacle pore wholly inside the mouth edge, not visible from the outside 10
2. Lateral plates of the innermost 2-5 arm-joints much widened 9
- Lateral plates of the innermost arm-joints not widened 3
3. Radial shields not present; dorsal side of disk covered almost exclusively by the primary plates, a very large central plate, and 5 large radially situated plates, which touch the base of the arms. Only one large, scale-like mouth papilla on each side of jaw *Ophiotypa* Koehler
- Radial shields present, the primary radial plates not touching the base of arms 4
4. Dorsal arm plates absent.² Disk covered almost exclusively by the large primary plates and radial shields.³

Aspidophiura Matsum.

Dorsal arm plates present; disk with more or less numerous small plates, among which the primary plates may be more or less conspicuous 5

¹ The second pair of tentacle (or tube-foot) pores is that corresponding to the innermost, often rudimentary, ventral plate, which abuts against the outer end of the mouth slit.

² The dorsal plates are absent in the N.E. Atlantic species of *Aspidophiura*; in other species small dorsal plates are developed.

³ Also in the young *Homalophiura inornata* the dorsal side of disk is covered exclusively by the large primary plates and radial shields; it is, however, distinguished from *Aspidophiura minuta* by having dorsal arm plates developed and, as a rule, the mouth shield divided by a longitudinal line. Likewise, *Amphiophiura convexa* has the dorsal side of disk covered almost exclusively by the primary plates and radial shields; it is distinguished from *Aspidophiura* by its well-developed dorsal arm plates and by the ventral plates being broadly in contact, these latter being widely separated in *Aspidophiura*.

(Lyman) (Syn. *Ophioglypha convexa* Lyman), found in various places between Madeira and the Azores ("Princesse Alice"), and in the Bay of Biscay ("Michael Sars"), 3825-4700 m.; also known from off New England ("Albatross") and from the S. Atlantic and the Pacific ("Challenger"), ca. 2940-4700 m.; *A. saurura* (Verrill) (Syn. *Ophioglypha saurura* Verrill; *Ophioglypha aspera* Koehler), found at 62° 10' N., 19° 36' W., 2060 m. ("Thor"), elsewhere known from off N. America, ca. 850-1270 m. ("Albatross", "Hirondelle"). These four species are distinguished as follows:

1. Mouth shields very large, occupying nearly the whole inter-radial space 2
 Mouth shields small, not reaching halfway to the edge of disk; plates of dorsal side of disk thick, small, with primary plates fairly conspicuous; radial shields separate or just meeting at the distal end. Arms serrate-carinate . . . *A. saurura* (Verrill)
2. Primary plates not separated by smaller plates, very large, occupying nearly the whole disk. Radial shields contiguous. ("Challenger" *Oph.*, Pl. VI. 13-15) . . . *A. convexa* (Lym.)
 Primary plates separated by smaller scales; radial shields not contiguous 3
3. Primary plates fairly large; pores very large, well beyond disk still having 4 tentacle scales at inner side
A. bullata (Wyv. Thoms.)
4. Primary plates not much larger than the other scales; already the fourth pore pair with only 2 tentacle scales at inner side, then only one ("Monaco", xxxiv., Pl. XXV. 9-11)
A. abdita (Koehler)

[*Homalophiura* H. L. Clark.]

The two species of this genus recorded from the N.E. Atlantic are: *H. inornata* (Lym.), (Syn. *Ophioglypha inornata* Lym.; *O. indivisa* Ltk. and Mrtsn.), found off the Azores and Canaries, 640-2995 m. ("Talisman"), known elsewhere from the Indo-Pacific, 470-3330 m.; *H. tessellata* (Verrill) (Syn. *Ophioglypha tessellata* Verrill), found off the Azores and from the Bay of Biscay to the Cape Verde Islands, 1267-2870 m.; also known from the east coast of N. America, 458-3720 m.¹ The two species are thus distinguished:

¹ In *Les Échinodermes des mers d'Europe* (p. 331) Koehler states that *Ophiura* (*Homalophiura*) *confragosa* Lyman has also been found off Portugal, in a depth of 1000-2000 m. This must rest on a slip of the memory. So far as the author can find, this species has only been found by the "Challenger" in the S. Atlantic, off the La Plata River, 1080 m.

Arm combs represented by a more or less distinct double series of granules; mouth shields usually undivided or with a small supplementary plate at inner corner. ("Monaco", xxxiv. Pl. XXV. 12-13, Pl. XXVII. 5-6) . . . *H. tessellata* (Verr.)

Arm combs small, but consisting of distinct papillæ; mouth shields usually divided through a longitudinal line. ("Challenger" *Oph.*, Pl. III. 10-12) . . . *H. inornata* (Lym.)

[*Ophiozonella* Matsumoto.]

The two species of this genus known from the N.E. Atlantic are: *O. molesta* (Koehler) (Syn. *Ophiozona molesta* Koehler), found off the Canaries, 2115 m. ("Talisman"), elsewhere known from the Malay Archipelago, 1270 m. ("Siboga"); *O. sincera* (Koehler) (Syn. *Ophiozona sincera* Koehler), found in the Bay of Biscay, 1226-1600 m. ("Talisman"). These two species, which have both of them a very conspicuous rosette of primary plates and two small arm spines, are thus distinguished:

A single large tentacle scale ("Talisman" *Oph.*, Pl. XVIII. 4-5)

O. sincera (Koehler)

Two tentacle scales, one outside the other ("Siboga" *Oph.*, i. Pl. VI. 3-5)

O. molesta (Koehler)

1. *Ophiura* Lamarck.

(Syn. *Ophioglypha* Lyman.)

Disk flat, covered with numerous small scales, among which the primary plates are usually inconspicuous. Edge of disk not sharp; usually there is a conspicuous notch above the base of arms, in which some rudimentary dorsal plates are situated; it has thus more or less the appearance of the arms issuing from the dorsal side of disk. On each side of the notch usually a more or less distinct comb of papillæ, continuing along the side of arm down to the ventral side and passing gradually into the genital papillæ along the bursal slits; more rarely the outer combs unite across the base of arms. Another pair of smaller combs of papillæ, the secondary arm combs, is found on the dorsal side of the base of arm, usually rather inconspicuous and covered by the outer comb. Ventral plates usually triangular, much broader than long, with a proximal angle; mostly they are widely separated, but a few of the proximal ones may be contiguous. Second tentacle pore outside the mouth edge, but usually opening into the mouth slit. The pores continuing to the

end of arm, but usually small and very inconspicuous beyond the proximal ones.

The very numerous species formerly referred to the genus *Ophiura*, or *Ophioglypha*, have now been separated into a number of minor genera, as *Amphiophiura*, *Homalophiura*, *Aspidophiura*, etc., but even as now restricted the genus *Ophiura* contains a large number of species, and, evidently, needs a further subdivision. In fact two minor genera have already been proposed, namely *Ophioglyphina* Ludwig (Syn. *Ophiozea* A. H. Clark), with *O. robusta* Ayres as type species, and *Diclenophiura* H. L. Clark, with *O. carnea* M. Sars as type species. Until a complete revision of the genus *Ophiura* has been undertaken it may, however, be preferable not to adopt these two genera or subgenera.

The biology of the various species would seem to be in the main alike. They are found on both hard (sandy) and on soft, muddy bottom, not buried in the ground, but moving freely about by means of their arms, as described above, p. 149. Their food they take by placing themselves directly above it, or they twist the end of an arm around it and thus carry it to the mouth. They eat all sorts of minor organisms, worms, crustaceans, molluscs, echinoderms, but also detritus forms an important part of their food, conveyed to the stomach by ciliary currents. As food for fishes they are of some importance; thus, *e.g.* *Ophiura texturata* and *albida* are eaten by haddock and dab.

Two of the species, *O. texturata* and *albida*, are known to have pelagic larvæ of the typical Ophiopluteus form; very probably this will be the case also with several more, at least of the littoral species; some of them, however, appear to have a shortened development, with a more or less rudimentary larva (*O. affinis* and, probably, *O. Grubei*).

Eight species of this genus are known to occur in the British seas, but several others are more or less likely to occur there also, namely: *O. clemens* (Koehler) (Syn. *Ophioglypha clemens* Koehler), found off Cape Finisterre, 1916 m. ("Talisman"), known elsewhere from the Malay Archipelago and the Philippine seas, ca. 700-1633 m. ("Siboga", "Albatross"); *O. concreta* (Koehler) (Syn. *Ophioglypha concreta* Koehler), found 45° 26' N., 25° 45' W., 3120 m. ("Michael Sars"), off the Azores, 2995 m. ("Talisman"), and off the Cape Verde Islands, 2478 m. ("Princesse Alice"); *O. flagellata* (Lyman) (Syn. *Ophioglypha flagellata* Lyman, *Gymnophiura cærulescens* Ltk. and Mrtsn.), taken off the African coast, between the Canaries and Cape Verde, 932-2330 m. ("Talisman"), known elsewhere from the Indo-

Pacific, from S. Africa to Japan, the smallest depth from which it is recorded being 96 m.; *O. Grubei* Heller, known from the Mediterranean and the Atlantic coasts of Morocco, 10-20 m.; *O. imprudens* (Koehler) (Syn. *Ophioglypha imprudens* Koehler),¹ from off the Azores, 560 m. (only one specimen known; "Talisman"); *O. inermis* (Lyman) (Syn. *Ophioglypha inermis* Lyman), found S. of the Canaries, 1786 m. ("Princesse Alice"), known elsewhere from off Tristan d'Acunha, 900 m. ("Challenger"); *O. irrorata* (Lyman) (syn. *Ophioglypha irrorata* Lym.; *O. mundata* Koehler, *O. orbiculata* Lyman; *O. involuta* Koehler; *O. tumulosa* Ltk. and Mrtsn.; *O. grandis* Verrill), found in the Bay of Biscay ("Caudan", "Talisman"), and off the Canaries ("Talisman"), otherwise of cosmopolitan distribution in warm and temperate seas, ca. 600-4315 m.); *O. lepida* (Lyman) (syn. *Ophioglypha lepida* Lyman), found off the Azores, 1620 m., S. of Iceland, 2060 m. ("Thor"), also known from the Atlantic coasts of N. America, ca. 1000-2235 m. The following key gives the main characters (with reference to figures) of all these species, together with those actually known from the British seas.

*Key to the species of Ophiura known from or likely to occur
in the British seas.*

1. Ventral plates in proximal part of arm separated by pores;
outer arm comb with numerous (ca. 30) papillæ

1. *O. texturata* Lmk.

No pores between proximal ventral plates; outer arm comb with fewer (7-15) papillæ, or rudimentary, or continuous across base of arms, or absent 2

2. First dorsal plate divided by a longitudinal line in two lateral halves 6. *O. carnea* M. Sars

First dorsal plate not divided by a longitudinal line 3

3. Arm combs absent. ("Challenger" *Oph.* Pl. VII. 4-6)

O. inermis (Lym.)

Arm combs continuous across base of arms. ("Siboga" *Oph.*, i. Pl. VIII. 7-9) *O. clemens* (Koehler)

Arm combs small, rather indistinct; mouth shields short and broad² 4

Arm combs well developed 5

¹ This species is referred by H. L. Clark to the genus *Amphiophiura*; in the opinion of the present author it more naturally belongs with the genus *Ophiura* proper.

² Perhaps *O. concreta* should rather be reckoned to the group with small, indistinct arm combs; from the two other species of the group, *O. robusta* and *irrorata*, it is easily distinguished by having the four proximal ventral plates broadly contiguous and nearly quadrangular.

Dorsal arm plates merely in contact on the proximal joints, with an acute proximal angle and a strongly convex, in the middle slightly elevated outer edge. Smaller scales of disk not forming regular circles around the primaries. *O. Grubei* Heller
 13. Mouth shields twice as long as broad. 7. *O. affinis* Ltk.
 Mouth shields scarcely longer than broad 8. *O. signata* (Verr.)

1. *Ophiura texturata* Lamarck. (Fig. 128, 3-4.)

(Syn. *Ophioglypha ciliaris* (Linn.) ; *O. ciliata* (Retzius) ; *O. lacer-tosa* (Pennant) ; *Ophiura ophiura* (Linn.) H. L. Clark.)

Scales of disk rather coarse ; primary plates fairly distinct, especially the central plate. Radial shields about half the length

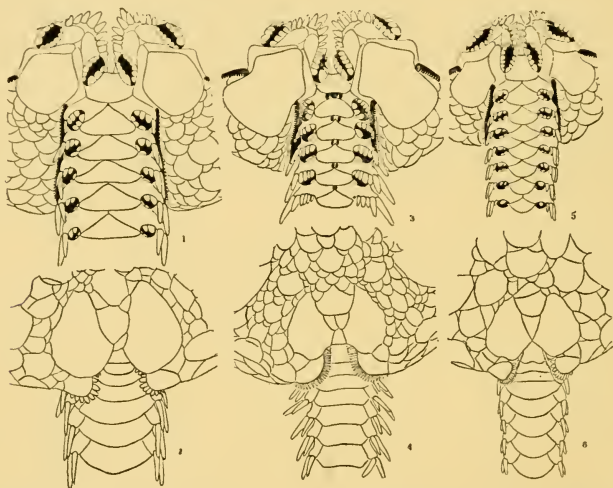


FIG. 128.—1-2. *Ophiura Sarsi*. 3-4. *O. texturata*. 5-6. *O. albida*. The upper figures represent part of the oral side, the lower figures of the dorsal side. $\times 4$. (From *Danmark's Fauna*.)

of the disk radius, separated or contiguous at their broadest part, just inside the innermost dorsal plate. Arm combs consisting of very fine, rather long papillæ, ca. 30 in the outer comb. The innermost of the dorsal plates in the notch above the arm (there are generally 4 of them) usually rectangular or triangular. The free dorsal plates in the proximal part of arms four to five times as broad as long, with straight or slightly concave outer edge, contiguous throughout their whole breadth. Dorsal side of arm somewhat roof-shaped. Ventral plates twice as broad as long, with convex outer edge ; they are not contiguous, but separated by a pair of sharply defined pore-shaped grooves in the mid-line

of the arm. These very characteristic grooves are, in younger specimens, distinct only in the proximal part of the arm, in larger specimens somewhat farther out. Three to four tentacle scales in the proximal part of arm, farther out 2 and distally only 1. At the innermost (*i.e.* second-third) pore pairs there are 2-3 broader papillæ on the outer edge of the pore, at the following 2-3 pairs only 1. Of the three arm spines the lowermost, which is placed close to the tentacle scales, is the shortest, only little longer than the tentacle scales; the second is the longest, about the length of an arm joint. The spines are placed at equal distances from one another. Mouth shields about twice as long as the distance from their outer edge to the edge of disk. Four to six pointed mouth papillæ. Colour in life reddish or reddish-brown, often

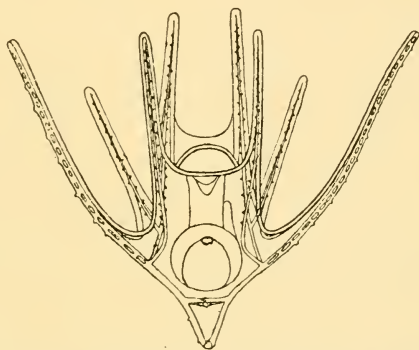


FIG. 129.—Larva (*Ophiopluteus*) of *Ophiura texturata*. \times ca. 25.
(From *Danmark's Fauna*.)

somewhat spotted. Oral side yellowish or white. Reaches a size of ca. 35 mm. diameter of disk; arms ca. three and a half times as long as the diameter of disk.

The larva (Fig. 129) differs from all other Ophiuroid larvæ known till now, in having fenestrated rods in the postero-lateral arms. It may be found throughout most of the summer. The young brittle-star reaches sexual maturity in its third year, at a size of 7-11 mm. diameter of disk. The very large specimens of ca. 30 mm. diameter of disk are probably 5-6 years old.

A parasitic Copepod, *Parartotrogus Richardi* Scott, of the family Asterocheridæ, appears to infest this Ophiurid (it has, however, not yet been directly observed to infest it). In the Limfjord, Jutland, where this Ophiurid occurs in great numbers, it is often infested with a small parasitic green alga, *Coccomyxa ophiuræ* Rosenvinge, which dissolves the calcareous skeleton and probably in the end kills the animal, like a sort of cancer.

In British seas this species occurs more or less commonly all round the coasts, from about lower tide limit to ca. 200 metres depth. At Fanö on the coast of Jutland, and on the French coasts, it has been observed above the lower tide limit; before the water disappears it buries itself in the sand, but it soon rises and tries to reach the water, a characteristic star-shaped groove in the sand showing the place where it had buried itself. It is distributed from Lofoten on the Norwegian coast to the Danish seas (not the Baltic), and farther to the Mediterranean and Madeira. It is not found at Greenland or the N. American coasts. In the Mediterranean it may be found in depths to 300 m.; elsewhere it scarcely goes deeper than 200 m.

2. *Ophiura Sarsi* Lütken. (Fig. 128, 1-2.)

(Syn. *Ophioglypha Sarsi* Ltk.)

Scales of disk rather coarse, primary plates generally distinct. Radial shields as in *texturata*. Arm combs consisting of short, rather broad papillæ, ca. 9-12 in the outer comb. The innermost of the dorsal plates in the notch usually triangular or rectangular. Dorsal and ventral plates of arm mainly as in *texturata*, but there are no grooves between the proximal ventral plates. The proximal (*i.e.* third) pore pair with 3-4 tentacle scales at the inner edge, the following ones with 2 tentacle scales, farther out only 1. The innermost pairs also have 3-4 scales at the outer edge, the following ones 2, those just outside the disk only 1 minute scale, which disappears at about the tenth pore pair. Arm spines 3, placed at equal distances from one another, often somewhat outstanding. In proximal part of arm the two uppermost spines are up to twice the length of a side plate, while the lower spine is somewhat shorter; sometimes also the upper spine is shorter than the middle one. Arms somewhat roof-shaped, arched. Mouth shields conspicuously shorter than the distance from their outer edge to edge of disk. Four to six pointed mouth papillæ. Colour in life reddish or darker, often somewhat mottled. In young specimens the distal part of the radial shields may be white, as in *O. albida* and *robusta*; in fact, the resemblance between *O. robusta* and *Sarsi* of a corresponding size may be so great that a closer examination is necessary for distinguishing them. Grows to about the same size as *O. texturata*; arms ca. four times the diameter of disk.

Development unknown; but there are reasons for suggesting that *Ophiopluteus compressus* (Fig. 3, 3 and 88, 6) may be the

larva of this species. With regard to growth it appears to correspond to *O. texturata*.

A peculiar parasite is found in this Ophiuroid (especially common in the Trondhjem Fjord), a red, sac-shaped organism of about peas size, without any special organs, but filled with eggs or embryos; to which group of animals this (as yet undescribed) parasite belongs is unknown. It lives in the genital organs of the brittle-star; by and by, as the parasite grows, the genital organs are destroyed.

In British seas this species is mainly confined to the Faroe Channel; it has also been recorded from the Rockall Bank and from off Cape Clear. This latter locality is, however, problematic, the identification of the specimen from there being doubtful (Hoyle). As the species goes as far south as Heligoland in the North Sea, it may probably occur also along the British North Sea coasts. It is circumpolar. At the Atlantic coast of N. America it occurs to 35° N., in the Pacific as far south as Japan and California. Bathymetrical distribution ca. 10-3000 m.

3. *Ophiura albida* Forbes. (Fig. 128, 5-6.)

(Syn. *Ophioglypha albida* (Forbes).)

Scales of disk rather coarse; primary plates not very conspicuous. Radial shields usually contiguous in their outer part, ca. $\frac{1}{3}$ as long as the disk radius. Arm combs with 10-12 short papillæ; inner arm combs small and indistinct. Three or four dorsal plates within notch, the innermost with concave outer edge, so as to be rather distinctly heart-shaped, a feature very characteristic of this species. Dorsal plates of arms with convex outer edge; the dorsal side of arms not roof-shaped arched. Ventral plates with convex outer edge, usually contiguous in proximal part of arm, but they may be distinctly separate, also in the proximal part. Only 1 tentacle scale, excepting the proximal 3-5 pore pairs, which have usually 2-3 scales; at the outer edge of the pore there is a small scale, until about the middle of the arm; the proximal pores may have 2-3 scales at the outer edge; 3 arm spines at equal distance from one another; the uppermost is the longest, reaches to the middle of the following lateral plate. Mouth shields reach about half-way to the edge of disk; 3-5 simple mouth papillæ on each side of jaw. Colour in life usually reddish-brown, the radial shields whitish. Reaches a size of ca. 15 mm. diameter of disk; arms ca. four times the diameter of disk.

The larva, *Ophiopluteus paradoxus* (Joh. Müller) (Fig. 88, 4),

is characterised by its broad arms, the rods of which are set with rather long, at a right angle outstanding thorns. Is especially common in August-September, but may be met with throughout most of the summer. Regarding growth and age it probably agrees with *O. texturata*. A specimen was kept in an aquarium for 2 years 8 months (Möbius).

The young stage of a Trematode, *Fellodistomum fellis* (Olsson), is found, to the number of 5-6, in the stomach of this Ophiuroid; the adult Trematode lives in the gall-bladder of *Anarrhicas lupus*, whose food to a large extent consists of echinoderms. A Cercaria (*C. capriciosa* Cuénot) has been found encysted in the peritoneum. Further, young stages of Nematodes may be found in the body cavity of this brittle-star, evidently belonging to some species of Nematode living in fish.

In the British seas this species occurs all round the coasts and appears to be common everywhere in not too deep water. It is distributed from East Finmark to the Mediterranean and the Azores. It is rather euryhaline and therefore able to live also in the Baltic (the western part, not beyond Bornholm). It is not found at Greenland or the Atlantic coast of N. America. Its bathymetrical distribution is ca. 4-850 m., but it is usually confined to the region beyond ca. 200 m.

4. *Ophiura Ljungmani* (Lyman). (Fig. 130.)

(Syn. *Ophioglypha Ljungmani* Lyman; *O. Thouleti* Koehler.)

Scales of dorsal side of disk rather fine; the central plate distinct, but the other primaries usually indistinct. Generally some fine spines are found scattered on the disk. Radial shields usually contiguous at the outer end. Arm comb consisting of ca. 8-10 very slender papillæ; the secondary comb fairly distinct; 2-3 somewhat elevated dorsal plates within the notch,¹ the innermost with rounded outer edge. Arms rather high, somewhat compressed, but scarcely roof-shaped on the dorsal side. Dorsal plates longer than broad, elongate pentagonal. Ventral plates widely separated, the outer edge convex, with a more or less distinct prominence in the middle. Pores large; the two proximal pairs with several scales at both edges; the scales at the distal edge do not continue beyond the fourth, at the proximal edge there are two scales beyond the fourth pair, and

¹ The figure erroneously shows only one very large dorsal plate within the notch, the transverse lines indicating the limits between the plates having inadvertently been omitted.

farther out there is only one scale, which also gradually disappears. Arm spines 3, very slender; the two lowermost ones short, placed close together close to the pore; the uppermost, longer, in the proximal part of arm about as long as an arm-joint, placed at the upper edge of the side plate. Mouth shield

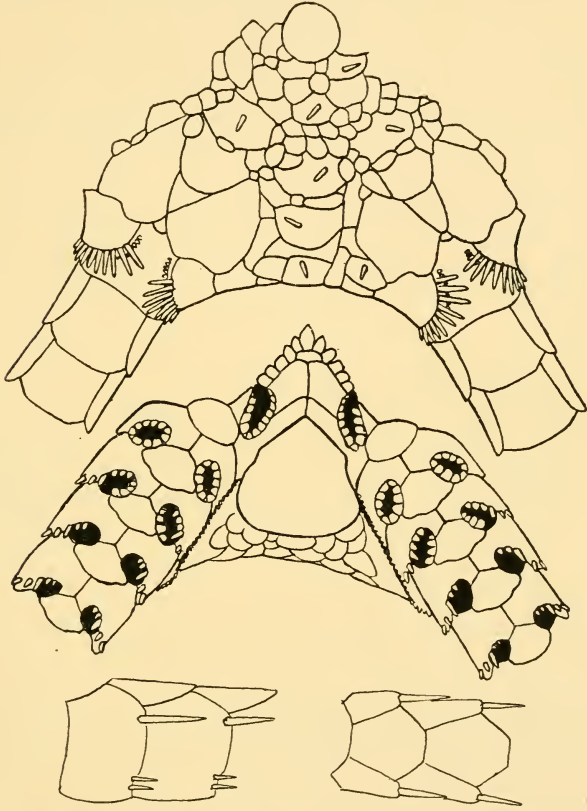


FIG. 130.—*Ophiura Ljungmani*; part of dorsal and oral side; below two arm-joints in side view (left) and from above (right). \times ca. 6. (The two upper figures from Farran, *Deep-water Ast. . . . Ireland*; slightly altered.)

broad, shield-shaped, reaching more than half-way to the edge of disk, which is rather high. About 4 rather coarse mouth papillæ on each side of jaw. Colour in life, reddish-violet. Reaches a size of ca. 9 mm. diameter of disk. Length of arms ca. three to five times the diameter of disk.

In British seas this species has been found at $50^{\circ} 48' N.$, $11^{\circ} 41' W.$, 1620 m., and $51^{\circ} 22' N.$, $12^{\circ} 41' W.$, 1765 m.

("Helga"). It is known elsewhere from the Bay of Biscay, off the Azores and Canaries; also known from the S. Atlantic. Bathymetrical distribution, 630-2400 m.

5. *Ophiura robusta* Ayres (Fig. 84, lower part of figure; Fig. 131, 1-2).

(Syn. *Ophiura squamosa* Lütken; *Ophioglypha robusta* (Ayr).)

Scales of disk rather coarse, uniform; only the central plate distinct, the other primaries usually indistinguishable. Radial shields small, scarcely one-third the disk radius; they may be in contact at their distal end. Arm combs only feebly developed, usually consisting only of a small irregular group of papillæ on each side at base of arm. Notch small, containing only 2 small dorsal plates, the innermost of which may sometimes be slightly heart-shaped. Arms not high, roof-shaped arched. Dorsal

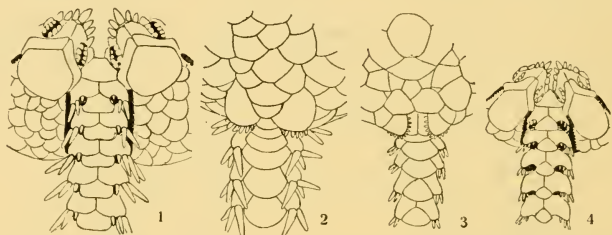


FIG. 131.—1-2. *Ophiura robusta*. 3-4. *O. carnea*. Part of oral and dorsal side. $\times 6$. (From *Danmark's Fauna*.)

plates rather narrow, with outer edge strongly convex; ventral plates with a slight concavity in the outer edge, usually widely separate and with a very obtuse proximal angle. Only one small tentacle scale; a few of the proximal pores may also have a small scale at the outer edge. Three arm spines, placed at equal distance from one another; the uppermost one considerably longer than the two others, about as long as an arm-joint. Mouth shields short and broad, scarcely reaching half-way to edge of disk. Three to four small, simple mouth papillæ on each side of jaw. Colour in life, bluish-grey or dark brownish, often with white spots, especially the radial shields usually whitish. Arms often somewhat banded. It is a small form, scarcely reaching a size of 10 mm. diameter of disk. Arms ca. three times the length of the diameter of disk.

Development unknown; no reasonable suggestion can be

made as to which of the known forms of Ophiuroid larvæ may belong to this species.

In British seas this species is known only from the North Sea coasts, from the Shetland Islands to Durham. It is not known from farther south on the European coasts; towards the north it goes as far as Spitzbergen and the Kara Sea. Also known from Greenland and the Atlantic coasts of N. America to Cape Cod. Possibly the North Pacific *O. maculata* Ludwig is the same species as *O. robusta*. Bathymetrical distribution ca. 6-450 m. (exceptionally as much as 1000 m.).

6. *Ophiura carnea* M. Sars. (Fig. 131, 3-4.)

(Syn. *Ophioglypha carnea* (M. Sars); *Dictenophiura carnea* (M. Sars).)

Disk somewhat high, covered with rather coarse scales of uniform size; primary plates indistinct. Radial shields contiguous distally, very small; in larger specimens scarcely larger than the other scales. Arm combs almost vertical, consisting of ca. 12 small papillæ; the inner comb fairly distinct. Two to three dorsal plates in the notch, the inner one almost vertical and divided by a median furrow into two lateral halves. Arms not roof-shaped arched. Dorsal plates contiguous only on the proximal joints; somewhat elevated at their outer edge, which is strongly convex. Ventral plates very small, triangular, with convex outer edge, separate in the whole length of arm. Three very small arm spines, placed at equal distances from one another. The proximal pore pairs with two small tentacle scales; farther out there is only one tentacle scale. Mouth shields large, longer than broad, reaching more than half-way to the edge of disk. Three to four mouth papillæ, the two outer ones somewhat broader than the inner ones. Colour in life, beautifully pink or reddish-brown. It is a small but rather robust form, which scarcely grows beyond a size of 7 mm. diameter of disk. Arms short, only ca. twice the diameter of disk.

Development unknown; but judging from the small size of the eggs it may be expected to have a pelagic larva.

In British seas this species has been found only off the west coast of Ireland, 215-ca. 400 m. ("Helga"). It is distributed elsewhere from the Trondhjem Fjord on the Norwegian coast to the Azores and Cape Verde and the Mediterranean. The bathymetrical distribution is ca. 50-1260 m.

7. *Ophiura affinis* Lütken. (Fig. 84, upper part ; Fig. 132.)(Syn. *Ophioglypha affinis* (Ltk.) ; *Ophiura Normani* Hodge.)

Disk flat and regularly covered with fine scales so arranged as to form a regular circle around the very conspicuous primary plates ; these latter are round, the small scales usually quadrangular. Radial shields small, only ca. $\frac{1}{3}$ the disk radius ; they are wholly separate. Arm combs consisting of ca. 7-9 short, flat papillæ ; the inner combs, which consist of ca. 10 somewhat smaller papillæ, are contiguous in the mid-line, thus forming a continuous comb above the arm base. A few papillæ are often found on the edge of disk in the mid-line of the notch, just above the secondary comb. The notch is small, containing only two small dorsal plates, the innermost one quite small, wart-shaped. Dorsal plates of arms very broad, roof-shaped ; ventral plates widely

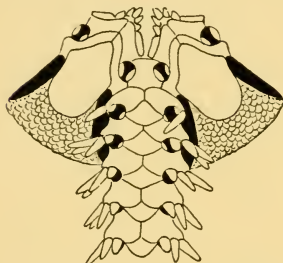


FIG. 132. — *Ophiura affinis* ;
part of oral side. $\times 8$.
(From *Danmark's Fauna*.)

separated, with a small, very obtuse proximal angle and very convex outer edge. Three small equidistant arm spines, the uppermost the longest, as long as an arm-joint. Only one rather broad tentacle scale ; the two proximal pore pairs also with a small scale at the outer edge. The second tentacle pore, which has likewise only one tentacle scale on each side, does not open into the mouth slit, contrary to all the species of *Ophiura* described above. Mouth shields large, twice as long as broad, as long as or longer than the distance from their outer edge to edge of disk. Mostly only 3 mouth papillæ on each side of jaw, the outer one very broad, scale-like. Colour in life reddish-brown or grey. It is a small and delicate form, scarcely exceeding 7-8 mm. diameter of disk ; arms ca. three times the diameter of disk. The arms very easily break off, if the specimens are not preserved immediately on being caught.

The *larva* not known with certainty, but very probably a somewhat rudimentary Ophiopluteus form (Fig. 133), with apparently only the postero-lateral arms well developed, white, untransparent, belongs to this Ophiuroid. This larva has been found only at the coast of Bohuslén (Sweden) in the beginning of August.

In British seas this species occurs all round the coasts, from

off Plymouth, round the Irish coasts to the north, and as far south as Dogger Bank along the North Sea coasts; also recorded from the Lousy Bank. In the area N. and W. of Shetland it is very numerous, and, together with *Echinocyamus pusillus*, characterises the animal community living there. It is elsewhere distributed from West Finmark to the Sound in the Scandinavian seas. It has also been recorded from the Bay of Biscay and the Mediterranean; but as it has previously been erroneously identified with *Ophiura Grubei* Heller, these statements are not reliable. Also the statement of its occurrence at the east coast

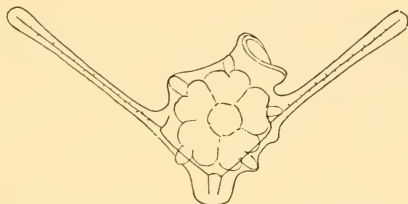


FIG. 133.—Ophiopluteus, probably of *O. affinis*. The larva is about to metamorphose, the young brittle-star being already distinct. \times ca. 50. (From *Danmark's Fauna*.)

of N. America is scarcely beyond doubt (see the following species). Bathymetrical distribution ca. 8-550 m.

O. affinis, together with the following species, recalls in several features the genus *Ophiocten*, and perhaps ought rather to be referred to that genus. Anyhow, it stands apart from the other species of *Ophiura*, especially through the second pore pair not opening into the mouth slit.

8. *Ophiura signata* (Verrill).

(Syn. *Ophioglypha signata* Verrill.)

Very closely resembling *O. affinis*, the only noteworthy difference being found in the shape of the mouth shields, which are in *O. signata* scarcely longer than broad, and scarcely reach half way to the edge of the disk. It may perhaps be questionable whether it can be maintained as a species separate from *affinis*.

In British seas *O. signata* has been found in the Faroe Channel, cold and warm area, and in considerable numbers off the west coast of Ireland, where it is stated to be one of the most characteristic species of the mud and ooze between ca. 500-900 m. Elsewhere recorded only from off the N. American east coast. Bathymetrical distribution ca. 110-900 m.

2. *Ophiocten* Lütken.

Disk flat, usually covered with small scales, among which the primaries are more or less conspicuous. Edge of disk usually sharp, forming a distinct limit between dorsal and oral side. Notch above arms feeble, the arms thus not having the appearance of issuing from the dorsal side. Usually a continuous comb of papillæ across the base of arms. Second tentacle pore outside, not opening into the mouth slit.

Two species known from the British seas, but two more have been recorded from the N.E. Atlantic, and may be expected to occur also in deeper water off Ireland; these are: *O. hastatum* Lyman (syn. *O. longispinum* Koehler), found off the Azores and off the N.W. coast of Spain, 1674-1940 m. ("Challenger", "Hirondelle", "Princesse Alice"), widely distributed in the Atlantic and (provided that Koehler is right in regarding *O. pacificum* Ltk. and Mrtsn. as a synonym of it) also the Pacific, ca. 235-2830 m.; *O. latens* Koehler, 42° 19' N., 23° 26' W., 4060 m. ("Talisman"), Bay of Biscay, 4380-4700 m. ("Princesse Alice", "Michael Sars"). These species are thus distinguished:

*Key to the species of Ophiocten known from or likely to
occur in the British seas.*

1. Mouth shield much longer than broad, reaching nearly to the edge of disk; tentacle scales very large
 2. *O. scutatum* Koehler
Mouth shield scarcely longer than broad, or broader than long, not reaching half-way to the edge of disk; tentacle scales small 2
2. Mouth shields distinctly broader than long; no papillæ along edge of proximal dorsal plates of arms. ("Talisman" *Oph.* Pl. XVIII. 11-12) *O. latens* Koehler
Mouth shields as long as, or a little longer than broad. Mostly a comb of papillæ along outer edge of proximal dorsal plates 3
3. Upper arm spine much longer than the 2 (3) lower ones, equalling in length $1\frac{1}{2}$ arm joints or more. ("Challenger" *Oph.* Pl. IX. 10-11; "Monaco", xii. Pl. VII. 32-33) *O. hastatum* Lym.
Upper arm spine not much longer than the lower ones
 1. *O. sericeum* (Forbes)

1. *Ophiocten sericeum* (Forbes). (Fig. 134.)

(Syn. *Ophiocten Kröyeri* Ltk.; *O. abyssicolum* (Forbes); *Ophioglypha gracilis* G. O. Sars; *Ophiocten Le Danteci* Koehler.)

Disk covered with numerous very fine scales, among which the primary plates are very conspicuous; in large specimens the small scales almost have the character of small granules; in young specimens the primary plates are surrounded only by a single circle of small plates. Radial shields narrow, widely separated, about $\frac{1}{3}$ the disk radius. Arms very distinctly roof-shaped. Dorsal plates of arms broader than long, the outer edge slightly convex; the proximal dorsal plates carry a series of fine papillæ along their outer edge; in larger specimens these papillæ may be found to the 15-16th arm-joint; in young specimens

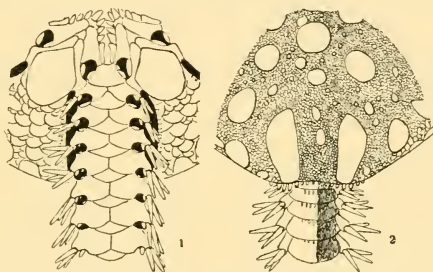


FIG. 134.—*Ophiocten sericeum* (Forbes); part of oral (1) and dorsal side (2).
× 4. (From *Danmark's Fauna*.)

they are only feebly developed, or may even be totally lacking. The papillæ along the edge of the disk above the base of arms may be confined to a small group at each side (corresponding to the outer comb in *Ophiura*). Ventral plates very small, with convex outer edge and a small, very obtuse proximal angle; they are widely separated. Three slender arm spines, about equally long, in the proximal part of arm slightly longer than an arm-joint. One small tentacle scale, the proximal 2-3 pairs, also with a small scale at the outer edge of the pore. Mouth shields scarcely longer than broad; 4-5 mouth papillæ on each side of jaw, the outer one broad, scale-like. Colour in life, bluish-grey to dark violet, nearly black; arms lighter. Grows to a size of ca. 18 mm. diameter of disk. Arms ca. four times as long as diameter of disk, rather slender and fragile.

Development unknown, but judging from the small size of the eggs it may be expected to have pelagic larvæ. Possibly

Ophiopluteus ramosus Mrtsn. may belong to this species. Biology unknown, but very probably as in *Ophiura*.

In British seas this species has been found in the Faroe Channel ("Porcupine"), also recorded from 77 miles W.S.W. of Fastnet, Cape Clear, 720 m. ("Research"). It is chiefly a cold-water species, distributed from the Arctic seas to Skagerrak, and from Greenland to Massachusetts. Bathymetrical distribution ca. 5-ca. 4500 m.

The Mediterranean *Ophiecten abyssicolum* (Forbes) seems to represent only a variety of *O. sericeum*, distinguished by the scales of the disk being slightly larger and less numerous, the arm spines shorter, and the papillæ on the dorsal plates less developed or even wanting. To this variety the specimens known from the British seas will probably belong. Likewise the form from the Bay of Biscay described under the name of *Ophiecten le Danteci* Koehler no doubt belongs here; at least all the characters given as peculiar to the single specimen known, 5 mm. of disk, are found equally developed in specimens of *O. sericeum* of a corresponding size.

2. *Ophiecten scutatum* Koehler. (Fig. 135.)

Disk with large primary plates surrounded by a regular circle of small, angular scales.¹ Radial shields smaller than the primary plates. Papillæ across the arm base apparently divided in two parts, a median part consisting of small, slender papillæ, and two lateral parts consisting of longer, club-shaped papillæ. No papillæ found along outer edge of the proximal dorsal plates of arm. These latter are very broad, roof-shaped, keeled. Ventral plates merely contiguous in proximal part of arms, farther out widely separated; they are small, with a convex outer edge and a small angle within. A single, very large, leaf-shaped tentacle scale, which covers the pore completely; on the proximal pairs there is also a narrow scale at the outer edge. Mouth shield much longer than broad, reaching nearly to the edge of disk; 3-4 mouth papillæ, the outer one very broad, scale-like. Colour in life unknown. Largest specimen known 8 mm. diameter of disk; arms ca. three times as long as diameter of disk.

Biology and development unknown.

¹ A quite similar arrangement of the disk scales being found also in young *O. sericeum*, it is probable that larger specimens of the present species may show a similar arrangement and character of the disk scales as is found in larger specimens of *O. sericeum*.

In British seas this species has been found at $50^{\circ} 03' N.$, $12^{\circ} 33' W.$, 147 m. ("Hirondelle"), and $59^{\circ} 03' N.$, $4^{\circ} 08' W.$,

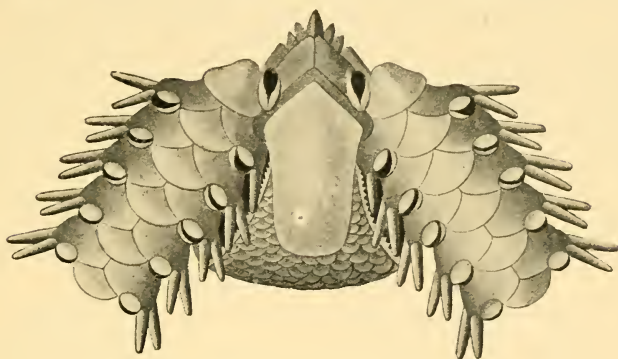


FIG. 135.—*Ophiecten scutatum*; part of oral side. $\times 10$.
(From Koehler, *Monaco*, xii.)

88 m. ("Princesse Alice"). Elsewhere known from the Bay of Biscay, 160 m., and off Newfoundland, 155 m. ("Hirondelle").

3. *Ophiopleura* Danielssen and Koren.

(Syn. *Lütkenia* Duncan, *non* Brock.)

Scales of disk very small, concealed by the skin. Edge of disk not sharp; a more or less conspicuous notch in the disk above the base of arms, but no arm combs. Otherwise as *Ophiura*.

The two species known of this genus are both found in the British seas.

Key to the species of Ophiopleura known from the British seas.

Ventral plates much broader than long, all separated. Genital slits short, not reaching to the edge of disk

1. *O. borealis* Dan. and Koren

Ventral plates scarcely broader than long, the proximal ones contiguous. Genital slits long, reaching to edge of disk

2. *O. aurantiaca* (Verrill)

1. *Ophiopleura borealis* Dan. and Koren. (Fig. 136.)

(Syn. *Lütkenia arctica* Duncan; *Ophiopleura arctica* (Duncan).)

Scales of disk, as seen on dried specimens, very small, irregular; primary plates very small, still fairly distinct. Radial shields widely separated, very small, oval, scarcely $\frac{1}{4}$ the disk radius, but they are seen to continue beneath the scales as more or less distinct ridges nearly to the centre of the disk. Notch

above arms, fairly deep, containing 3-4 rudimentary dorsal plates. Arms rather broad, flattened below, roof-shaped arched above. Dorsal plates of arms much broader than long, with outer edge straight or concave. Ventral plates very short and broad, with outer edge straight and with a small peak within; beyond the disk they are triangular; they are widely separated, at most the two first contiguous. Pores in proximal part of arm with several tentacle scales; beyond the disk there are only 2, farther out only 1 scale. Three very small arm spines, placed at about equal distances from one another, decreasing in size from the lowermost upwards. Mouth shields rounded triangular;

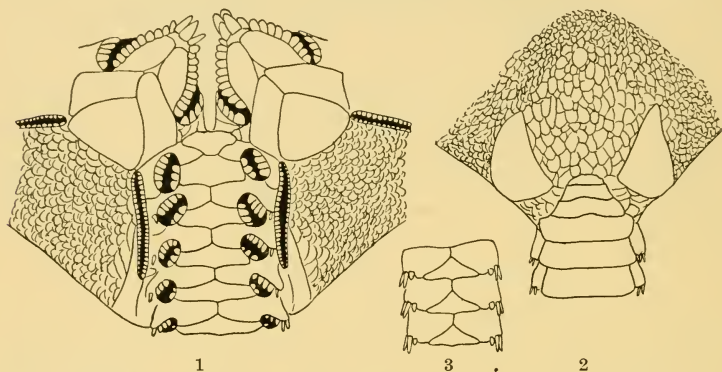


FIG. 136.—*Ophiopleura borealis*; part of oral (1) and dorsal side (2), three arm joints from ventral side (3). $\times 3$.

5-6 close set, small mouth papillæ, those on the apex of jaw somewhat enlarged. In large specimens there are generally some supplementary series of teeth, so that these, apparently, have tooth papillæ. Genital slits short, not reaching to the edge of disk, distinctly papillate along both edges. Colour in life red or orange, sometimes bluish between the radial shields. Grows to a very considerable size, up to 45 mm. diameter of disk, and is one of the largest of Ophiuroids. Arms ca. five times as long as the diameter of disk.

Development unknown. Biology probably as in *Ophiura*.

In British seas this magnificent species has only been found in the cold area of the Faroe Channel, $60^{\circ} 57' N.$, $4^{\circ} 38' W.$, 1098 m. ("Michael Sars"). It is a purely arctic species, characteristic of the cold area of the Norwegian Sea, distributed from east Greenland to Spitzbergen, Franz Joseph Land, and the Siberian Sea as far as $124^{\circ} 41' E.$ Bathymetrical distribution ca. 10-1400 m.

2. *Ophiopleura aurantiaca* (Verrill). (Fig. 137.)(Syn. *Ophioglypha*, *Ophiura aurantiaca* Verrill.)

Scales of disk very small and indistinct; primary plates usually not distinguishable. Radial shields small, rounded, widely separate, forming only short ridges beneath the scaling, and usually these ridges are not distinct. Notch above arms

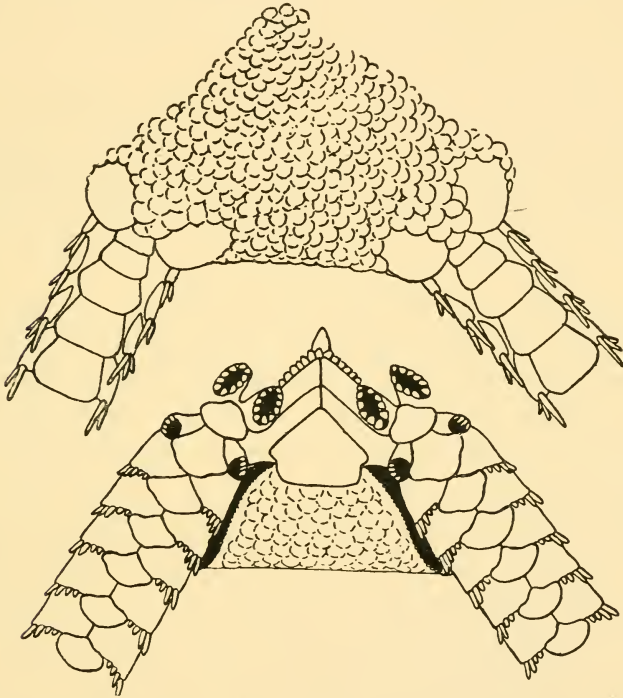


FIG. 137.—*Ophiopleura aurantiaca*; part of dorsal and ventral side. \times ca. 6.
(After Farran, *Deep-water Ast.* . . . Ireland; slightly altered.)

inconspicuous, with 1-3 rudimentary dorsal plates. Arms not roof-shaped, not flattened below. Dorsal plates about as long as broad, rounded quadrangular. At base of arm there is a fairly conspicuous naked part between the dorsal and the lateral plates. Ventral plates with convex outer edge, sometimes with a median prominence, the proximal ones in contact. Pores small, excepting the second pair. The third pair with 3-4 small papillæ, the following ones with 2 and then soon only 1. Arm spines 3; the upper one about as long as an arm joint, flattened,

the next only about half that length, and the lowermost one quite small, hardly to be distinguished from a tentacle scale. Mouth shields about as broad as long, with a small side lobe and a straight outer edge. Mouth papillæ very small, close set. Genital slits reaching to edge of disk, papillate only along their outer interradi al edge. Colour in life bright orange. Most specimens known are of a small size, up to 18 mm. diameter of disk, but a specimen taken in the Bay of Biscay ("Princesse Alice") is recorded measuring 40 mm. diameter of disk. Arms ca. three to four times as long as diameter of disk.

Development and biology unknown.

In British seas this species has been found off S.W. Ireland, 50° 34' N., 11° 19' W., ca. 1200 m. ("Helga"), and in the Faroe Channel, warm area ("Knight Errant", "Triton", "Michael Sars"), ca. 800-1300 m. Also found in the Bay of Biscay and at the Azores, 1490-1740 m. ("Princesse Alice"). Further known from the east coast of N. America, ca. 280-1725 m.

4. *Ophiomusium* Lyman.

Disk mostly covered with larger, thick, often granulated plates, not with imbricating scales. No arm combs. Arms rigid. Dorsal and ventral plates of arms rudimentary, arm spines very small, rudimentary. Tentacle pores confined to the proximal arm joints. Second tentacle pore within the mouth slit, not at all visible from the outside.

Only one species known from the British seas, but four others are more or less likely to occur there also, namely: *Ophiomusium africanum* Koehler, found S.W. of the Cape Verdes, 219 m. (only one specimen known, "Princesse Alice"); *O. armigerum* Lyman, off Madeira, 2970 m. ("Challenger"), also known from the Southern Atlantic and the West Indies, ca. 1580-3960 m.; *O. planum* Lyman, from the Bay of Biscay and the Azores down to the Cape Verdes, ca. 260-4060 m., also known from the West Indies and the Bay of Bengal, ca. 2325-5000 m.; *O. scalare* Lyman, Cape Verde Island, 225 m. (a young specimen only, "Talisman"), elsewhere only known from the Indo-Pacific, where it is widely distributed, ca. 200-1100 m. These species are thus distinguished:

Key to the species of Ophiomusium known from or likely to occur in the British seas.

- | | |
|--|---|
| 1. Only 2 pore pairs; no papillæ along genital slits. | 2 |
| 3-4 pore pairs; papillæ along genital slits; a rudimentary arm comb may be present | 4 |

2. Dorsal plates present, though very small, nearly to end of arm ;
ventral plates present on both tentacle-bearing joints, but
not beyond 3
No dorsal plates ; a ventral plate present only on the first tentacle-
bearing joint *O. africanum* Koehler
3. Arm spines 6-8 ; no conspicuous rosette in centre of disk
1. *O. Lymani* Wyv. Thoms.
Arm spines 3 ; usually a conspicuous rosette in centre of disk
O. scalare Lyman
4. Only the two first dorsal plates contiguous. *O. planum* Lyman
Some 5-6 of the proximal dorsal plates contiguous¹
O. armigerum Lyman

1. *Ophiomusium Lymani* Wyv. Thomson. (Fig. 138.)

Dorsal side of disk somewhat elevated ; in the centre a group of small, angular plates, among which the primary plates may be more or less distinct. From the central group radiate ten

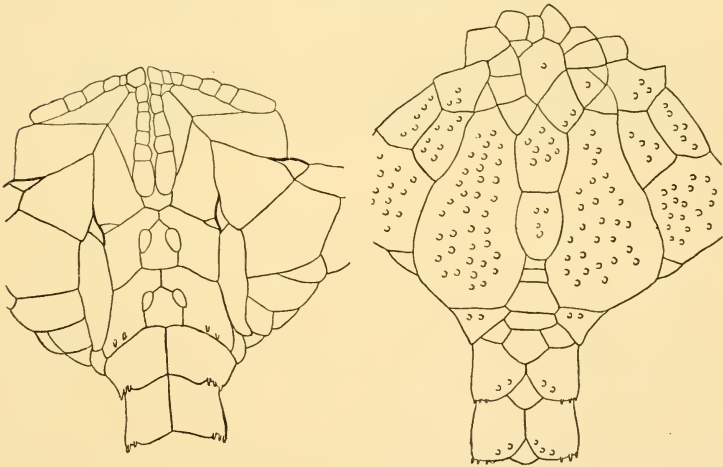


FIG. 138.—*Ophiomusium Lymani* ; part of oral and dorsal side. $\times 4$.

series of larger plates, one series in each interradius and one between each pair of radial shields, which latter are large, about half as long as the disk radius. All the larger plates of the dorsal side distinctly tuberculated. Dorsal plates of arms small, triangular, widely separated already from the first free arm-

¹ The two species *O. planum* and *armigerum* would seem to be so closely related as to be hardly distinguishable, unless the difference in the dorsal plates given in the key proves to be constant ; from literature this cannot be seen, and the material of the two species available to the author is not sufficient to judge of the constancy of this character.

joint. Ventral plates present only on the two proximal arm-joints; they are small, pentagonal, separate. Tentacle pores only on the two proximal joints, covered by a fairly large, leaf-shaped tentacle scale. Usually 6-8 short, rudimentary arm spines. Mouth shields small, triangular; outside the mouth shield a large pentagonal plate, which occupies nearly the whole interradian space, between the genital scales. Genital slits very short, reaching only to the proximal end of the first side arm plate, without papillæ along the edges. The whole underside of disk and arms very flat; arms rather slender, but rigid. Colour in life yellowish-brown. Grows to a size of ca. 35 mm. diameter of disk. Arms ca. six times as long as diameter of disk.

Biology and development unknown; but it seems certain that it takes 3-4 years to reach full size.

In British seas this species was first found by the "Porcupine", but there is uncertainty about the exact locality where it was taken. Later on it was taken by the "Helga" off S.W. Ireland, 1620-1768 m., sometimes in great numbers, and by the "Michael Sars" at 57° 41' N., 11° 48' W., 1853 m. It is elsewhere widely distributed both in the Atlantic and the Indo-Pacific; a truly cosmopolitan deep-sea form. Bathymetrical distribution 130-3435 m.

IV. Class. SEA-URCHINS OR ECHINOIDS

(ECHINOIDEA)

Free-living echinoderms, with globular, egg-shaped, or flattened body; a compact, mostly hard test, formed by regularly arranged plates, carrying spines articulated movably to tubercles on the test. Tube-feet in 10 meridian series, not in furrows; a double pore in the test corresponding to each tube-foot. Intestine long and coiled. Mouth turning downwards. Anal opening always present.

The *body* of the sea-urchins is usually globular or egg-shaped; in the order of the Clypeastroids (mainly tropical forms) it is usually flattened, often quite thin, disk-shaped. They may reach a considerable size, up to about 8 inches in diameter. The skeleton consists of very regularly arranged, usually pentagonal, plates, the *coronal plates*, which are usually coalesced so as to form a hard test. Only in some of the oldest, palæozoic forms and in the recent family of the Echinothuridæ the test is thin and movable, the plates being imbricated. The *test* (Fig. 139), or *corona*, is

divided into 10 regular areas, each formed by a double series of plates. Five of these areas carry each two series of tube-feet, and thus correspond to the arms of sea-lilies, sea-stars, and brittle-stars. These areas accordingly are radial and are designated the *ambulacral areas* or simply *ambulacra*; the areas situated alternating between the ambulacra are interradial and are designated the *interambulacral areas* or *interambulacra*. In each area there is usually a double series of larger "primary" tubercles. Generally the interambulacra are conspicuously broader than the ambulacra, and their tubercles distinctly larger than those of the latter. In

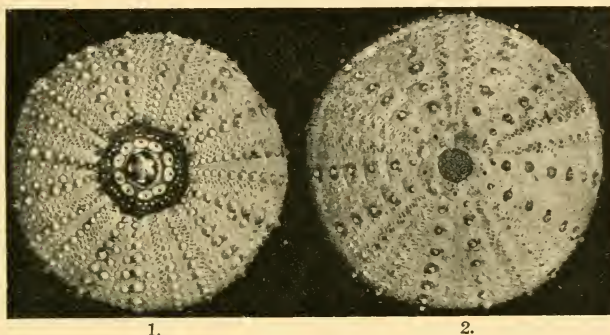


FIG. 139.—Test of *Echinus elegans*, from the under or oral (1) and the upper side (2). The areas with the two series of small tubercles are the ambulacra, those with the two series of larger tubercles the interambulacra. Outside the tubercles in the ambulacra are seen the pores of the tube-feet. In the middle of the upper side is seen the apical system, in the middle of under side the mouth area, in the centre the mouth with the five teeth. Round the mouth opening are the five pairs of buccal plates, and outside these very small, scattered plates in the skin of the peristome. In the edge of the mouth area are seen five pairs of small cuts in the test, the gill-cuts. Slightly diminished. (From *Danmark's Fauna*.)

the oldest known Echinoid (*Bothriocidaris*) the interambulacra have only a single series of plates, and a vestige of this arrangement is still found in the other Echinoids, in the first interambulacral plate always being single (in some forms it disappears during growth). In the other palæozoic forms there are more than two series of plates, either in the ambulacra or in the interambulacra; all other Echinoids, with a very few exceptions, have two series of alternating plates in each area. In several forms the plates of the ambulacra coalesce, forming thus compound plates, which carry as many tube-feet (and pore-pairs) as there are small plates (*primary plates*) contained, each ambulacral plate having originally one tube-foot. In such compound plates the tube-feet are arranged in regular arcs, 3 or more, up to 9-12,

in each arc. The tube-feet are always situated near the outer edge of the plate, and there, accordingly, the corresponding pore series are found on the naked test. Forms with three pairs of pores in each compound plate are found on the naked test. Forms with three pairs of pores in each compound plate are designated "*oligoporous*", those with more than three pairs of pores in each compound plate

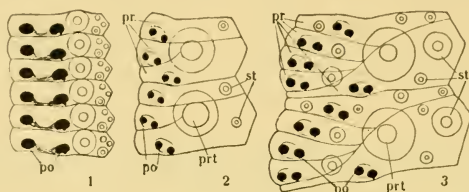


FIG. 140.—Ambulacral plates of various Echinoids. $\times 6$.

(From *Danmark's Fauna*.)

1. Simple ambulacral plates of *Eucidaris tribuloides*. 2. Compound, oligoporous plates of *Echinus elegans*. 3. Compound, polyporous plates of *Strongylocentrotus dröbachiensis*. po, Pores of the tube-feet; pr, Primary plates; prt, Primary tubercles; st, secondary tubercles.

"*polyporous*" (Fig. 140). This is a character of very great systematic importance. In the living animal the test is covered with a thin, ciliated skin. It is thus really an *inner skeleton*, like the skeleton of the vertebrates, *not* an outer test that encloses

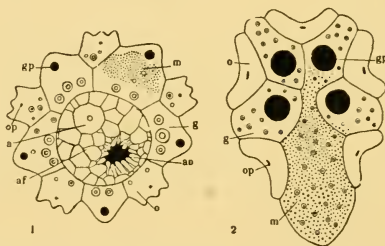


FIG. 141.—Apical system of Echinoids. $\times 6$.

(From *Danmark's Fauna*.)

1. Of a regular form, *Strongylocentrotus dröbachiensis*. 2. Of an irregular form, *Spatangus purpureus*. a, Anal plate; af, Anal area; an, Anal opening; g, Genital plate; gp, Genital pore; m, Madreporite; o, Ocular plate; op, Ocular pore.

the body of the animal, as is the case with the shell of the molluscs.

In the middle on the upper side is situated a small, distinctly limited area, the *apical system* (Fig. 141), consisting of a circle of 10 plates, 5 situated radially, off the ambulacra, designated the *ocular plates* or *oculars*, and 5 situated interradially, off the interambulacra, designated the *genital plates*, because the openings of the genital organs are situated in them. In the

oblong, "irregular" forms the posterior genital plate is lacking. The right anterior genital plate also has the function of a *madreporite*; in the Irregularia it is usually prolonged backwards, separating the other plates of the apical system (Fig. 141, 2). A small pore is also found in the ocular plates, through which the end of the radial water-vessel protrudes as a small, unpaired feeler, which does not, however, carry an eye, such as is the case in the sea-stars. Inside the circle of the 10 apical plates there is situated, in the round or "regular" forms, a small area covered with irregularly arranged, movable small plates, the *anal area* or *periproct*, and herein the anal opening is situated, often somewhat eccentrically towards the right posterior edge. One of the plates of the anal area may be conspicuously larger than the rest of them, and is then designated the *anal plate* (Fig. 141, 1). In the irregular Echinoids the anal area has moved outside the apical area to the posterior edge of the test or even down to the under side, close to the mouth. The *mouth* is on the under side of the test; in the regular forms it is situated in the centre, in a small, round, soft-skinned area, the *mouth area* or *peristome*, which is usually covered, more or less, by small plates, but may sometimes be quite naked, excepting for a pair of plates off each ambulacral area, the *buccal plates*, each of which carries a tube-foot. In some of the Irregularia the peristome has moved towards the anterior end of the test; it is in this group of Echinoids usually transverse-oval, wholly covered by small plates, none of which carry tube-feet.

To the test and peristome various appendages or organs are attached, namely spines, pedicellariæ, sphæridiæ, tube-feet, and gills. The *spines* are articulated to *tubercles* on the test; these latter generally have the shape of a truncated cone, the "boss," with a rounded head or condyle, the "mamelon," on the top. At the base of the spine is found a serrated, ring-shaped widening, the "milled ring", from which proceed muscles which attach to the test round the tubercle, and by means of which the spine can be moved in all directions. In some forms an elastic string proceeds from the centre of the base of the spine, attached with its other end in a groove in the top of the mamelon. Such a tubercle with a central hole in the mamelon is designated "*perforate*". On the larger tubercles, the *primary tubercles*, there is a distinct platform under the mamelon; it may be indented in the edge, in which case the tubercle is said to be "*crenulate*". The larger tubercles are surrounded by a more or less distinct, in some forms (especially the Cidarids) distinctly

deepened, circular area, the “*areole*” (Fig. 142), the place of attachment of the spine muscles.

The *spines* are usually rather long, in some tropical forms (*Diadema*) even about a foot long; usually they are cylindrical, tapering, but they may be greatly thickened, egg-shaped, or compressed. In the irregular Echinoids they are partly transformed into flat, spade-shaped digging apparatus, while others are very small, club-shaped, close set, forming peculiar bands, the “*fascioles*”, which have a definite course, different in the various forms and therefore of great systematic importance. While in the irregular Echinoids the spines are, as a rule, small, very numerous and crowded, without definite order, they are in the regular Echinoids usually large, rather few, and regularly arranged. Generally there is a larger spine in the centre of each

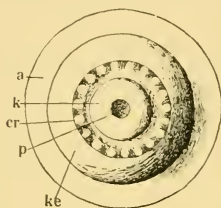


FIG. 142.—Perforate, crenulate tubercle of an Echinoid (*Echinothrix Desori*). $\times 6$. (From *Danmark's Fauna*.)

a, The areole; cr, The crenulate edge of the platform; k, The mamelon; ke, The tubercle cone, the “boss”; p, The groove or pit in the mamelon.

plate, and these *primary spines* then form a conspicuous longitudinal series to each series of plates. The smaller, *secondary spines* may also form regular longitudinal series, mainly at the circumference, the “*ambitus*”, of the test, where, as a rule, the tubercles and spines are most strongly developed. A corresponding arrangement, of course, is shown by the tubercles on the naked test (Fig. 139).

The *pedicellariæ* (Fig. 143) are small, delicate seizing organs, which are found scattered among the spines,

and, like these latter, are articulated to tubercles on the test, these tubercles being, however, very small, much smaller than the spine-bearing tubercles. They consist of a head and a stalk, to which latter the head is attached either directly, through muscles, or through a long, very flexible neck. The head consists of usually 3 valves, more rarely only 2 or 4, or even more, each with its very characteristic calcareous skeleton (Fig. 144). The 3 valves are connected with each other by strong muscles, and are thus able to open and close. On the inner side of each valve is found, as a rule, a small elevation provided with fine sensory hairs. If anything touches these hairs, the valves close instantly. The pedicellariæ are a sort of weapons of defence, which seize any foreign organism that comes into contact with the animal; they do not release their hold as long as the object moves, and if it is too strong to be held, the pedicellariæ are torn from the test of

the sea-urchin, but remain biting the foreign organism ; such detached pedicellariæ may remain alive for at least several hours.

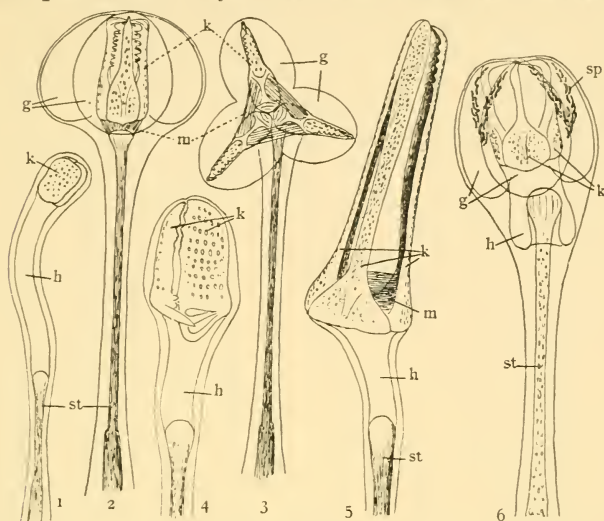


FIG. 143.—Various forms of Pedicellariæ. (From *Danmark's Fauna*.)

1. Triphyllous pedicellaria of *Psammech. miliaris*. 2-3. Globiferous pedicellaria of *Ps. miliaris*: 2, closed; 3, opened. 4. Ophicephalous pedicellaria of *Ps. miliaris*. 5. Tridentate pedicellaria of *Echinus acutus*. 6. Globiferous pedicellaria of *Strongylocentrotus dröbachiensis*. 1-4, $\times 45$; 5, $\times 12$; 6, $\times 35$. g, Poison gland; h, Neck; k, Valves; m, Muscles; sp, Spicules; st, Stalk.

The pedicellariæ also seize and remove small impurities, handing them from one to another, until they can be dropped outside the

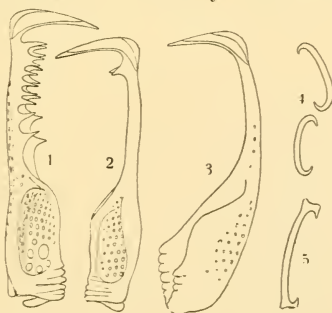


FIG. 144.—Isolated valves of globiferous Pedicellariæ, in side view.

(From *Danmark's Fauna*.)

1. Of *Psammech. miliaris*. 2. Of *Echinus acutus*. 3. Of *Strongylocentr. dröbachiensis*. 4. Spicules from tube-feet and pedicellariæ of *Echinus acutus*. 5. Spicule from tube-foot of *Strongylocentr. dröbachiensis*. 1, 4, and 5, $\times 100$; 2 and 3, $\times 35$.

animal. The fæces are stated to be removed in the same way ; however, the spines also play a part in this process. The

pedicellariæ are exceedingly varied in structure. Usually they are found of four different types, namely the *globiferous* pedicellariæ, which usually carry poison glands on the valves, the *tridentate*, *ophicephalous*, and *triphyllous* pedicellariæ (Fig. 143). In some forms (Cidarids) the ophicephalous and triphyllous pedicellariæ, in others (Saleniids, Arbaciids) the globiferous, are lacking; in others (Spatangoids), again, a fifth form, the *rostrate* pedicellariæ, are found. These peculiar, small organs are of very great systematic importance and will be mentioned more in detail under the various groups.

The *sphaeridia* (Fig. 145) are quite small, glassy, spherical or oval bodies, attached in the middle of the ambulacra or near the tube-feet, from the edge of the peristome some way upwards on the test. They are lacking in the Cidarids; in the Clypeastroids they are concealed in grooves in the test. They are supposed to have the function of static or of taste organs. For classification they are of very small importance.



FIG. 145.—Lower part of ambulacral area of *Strongyloc. dröbachiensis*, showing in the mid-line between the two series of tubercles a series of sphaeridia. Somewhat enlarged. (After Lovén; from *Danmark's Fauna*.)

The tube-feet in the regular Echinoids end in a sucking disk, containing a beautiful calcareous skeleton composed of various parts. As a rule the foot contains more or less numerous *spicules* of various forms, irregular rods, or C-shaped bodies ("bihamate" spicules) (Fig. 144, 4). In the Spatangoids the tube-feet are very diversified,

penicillate, leaf-shaped, or quite small and simple; in the Clypeastroids they are usually very small and numerous, spreading also over the interambulacral areas. Especially in the regular Echinoids and, partly, the Spatangoids the tube-feet are exceedingly extensible. To each tube-foot, excepting the small, simple ones in Clypeastroids and Spatangoids, correspond two pores in the test.

The *gills* are bush-shaped outgrowths from the peristomial membrane, 10 in number, one pair at each interambulacrum. On the test is seen a cut in the peristomial edge, more or less deep, corresponding to each gill (Fig. 139, 1). In the Cidarids and the irregular Echinoids gills are lacking.

The *mouth* is in the regular Echinoids and the Clypeastroids provided with 5 strong *teeth*, which are fastened in a very complicated apparatus, the so-called "Lantern of Aristotle" (Fig. 146),

somewhat different in structure in the various groups, and therefore of considerable systematic importance. Each tooth is enclosed by two larger pieces, which form together a "pyramid"; on their upper end are found a pair of smaller pieces, the "epiphyses", which may join in the mid-line and thus form an arch over the pyramid (the "camarodont" type, Fig. 146, 1), or they may be shorter so as not to join in the mid-line (the "stirodont" type, Fig. 146, 2). Above the interspace between each two adjoining pyramids lies an unpaired piece, the "rotula", and above this again a slender, arched piece, the "compass", the outer end of which is usually heart-shaped. To the pyramids are attached muscles for protruding and retracting the dental apparatus; their other end is attached to the "auricles", internal processes from the test at the peristomial edge. The pyramids are connected with each other by short but powerful "interpyramidal" muscles, the masticatory muscles proper. In addition there is a pair of muscles from the outer end of the compass, and a muscle which connects all the five compasses, thus forming a pentagon on the upper side of the dental apparatus. The

teeth, which consist of a hard, enamel-like substance, are constantly growing at their upper ends, and are pushed out steadily as the point wears off. They may be concave or have a longitudinal keel on the inner side. All Spatangoids lack teeth and tooth apparatus completely. In some Cassidulids teeth have been found to exist in the young; they are, however, soon resorbed, and the adult form lacks teeth completely.

The *intestinal canal* is a simple tube, attached to the test by means of strong mesenteries; it runs first nearly all round along the test, then bends directly back on itself, finally opening through the anus. Thus it does not form a real spiral coil. In the irregular Echinoids there is a large blind gut issuing from the intestine, and a small, thin "siphon" running close along the intestine and opening into it at both ends. A pair of blood-vessels accompany the intestinal tube, being connected with a network of blood-sinuses in its walls.

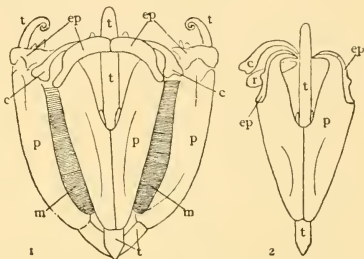


FIG. 146.—Dental apparatus of regular Echinoids. $\times 3$. (After Jackson; from *Danmark's Fauna*.)

1. Of *Strongylocentrotus dröbachiensis* (camarodont type). 2. A single pyramid of the dental apparatus of *Arbacia* (stirodont type). c, Compass; ep, Epiphysis; m, Interpyramidal muscle; p, Pyramid; r, Rotula; t, Tooth.

The *genital organs* lie in a circle round the apical system ; they are large, bush-shaped organs, from each of which a narrow efferent duct issues, opening through the pore in the genital plate. The regular Echinoids have 5 genital organs (or gonads), which coalesce in some forms ; in the irregular Echinoids the posterior gonad has disappeared, and the number of the gonads (and genital pores) may further be reduced to three or even two.

The *watervascular ring* lies on the upper side of the dental apparatus. *Polian vesicles* are represented by some small bushy outgrowths from the ring canal ; only in the family of the Echinothurids they are large sausage-shaped sacs. The radial water-vessels and the ampullæ of the tube-feet lie wholly inside the test, along each ambulacral area ; the same is the case also with the *nervous system*. *Axial organ* and *stone canal* pass directly through the body cavity from the œsophagus to the apical system.

The sea-urchins move slowly, especially by means of the spines on the oral side of the test, on which they walk almost as upon stilts. The tube-feet are more used for climbing, *e.g.* on rock walls or the walls of aquaria. Several forms make holes in the rocks, mainly by means of their teeth. The irregular forms are mostly burrowing animals, which live buried, as much as a couple of decimetres deep, in the ground. Many species cover themselves with small stones, shells, pieces of algæ, etc., which they hold tightly with their tube-feet, probably with the object of concealing themselves both from their enemies and from too strong light. Some forms have been observed to lie concealed during the day under stones or the like, coming out to feed at night. The regular forms feed largely on algæ, but also take all sorts of animal food. The irregular Echinoids eat all sorts of small bottom organisms, especially mussels, snails, Foraminifera, which they are able to pick out from the bottom material by means of their penicillate tube-feet ; or they fill their alimentary canal with all sorts of bottom material, absorbing the organic particles contained therein. About the *growth* and age only very little is known. As a rule they appear to reach sexual maturity in the course of one to two years. *Echinus esculentus* has been observed to reach full size in the course of four years. Evidence has been brought forward by Grieg tending to show that *Stylodidaris affinis* takes at least two years in reaching maturity, while *e.g.* *Phormosoma placenta* would seem to take four to five years in reaching full size. The power of *regeneration* is great ; not only spines and the other external organs are easily

regenerated, but even rather large fractures of the test are healed. Autotomy is not known to occur in the Echinoids.

Parasites are found in good numbers in Echinoids. Various Infusorians (*Colpidium echini* Russo, *Cryptochilum echini* Maupas, *Anophrys echini* Di Mauro) occur in the intestinal canal of regular Echinoids; Sporozoa may be found in the intestinal wall in Spatangoids. Two forms of Nematodes, *Oncholaimus echini* Leydig and *Ichthyonema Grayi* Gemmill and Linstow, are known from the body cavity and intestinal canal of *Echinus esculentus*, also a Planarian, *Syndesmis echinorum* Shipley, from the same species, and from several other regular Echinoids. In a Japanese Echinoid, *Mespilia globulus*, a Trematode is commonly found in the gonads. Various Gastropods (*Stylifer*, *Pelseneeria*, *Mucronalia*) live boring into the test of Echinoids. Various Copepods are found living on Echinoids, e.g. *Astrocheres echinicola* Norm. on *Echinus esculentus*; one species, *Pionodesmodes phormosomæ* Bonnier, forms internal galls on the test of *Hygrosoma Petersii*, another, *Echinocheres globosus* H. J. Hansen, forms galls in the spines of a Pacific Echinothurid, *Aræosoma gracile*. In a South American Echinoid a small crab lives in the rectum, causing irregularities in the apical system of this species. Another crab, *Zebrida Adamsii* White, lives on various tropical sea-urchins, devouring their spines and tube-feet. It is peculiarly striped so as to resemble the spines of the Echinoid on which it lives, a peculiar kind of protective coloration. On a tropical Echinoid, *Diadema*, with very long, pointed spines, small fishes and shrimps have been observed to seek shelter among the spines. In the Cidarids the spines are often overgrown with foreign organisms, Bryozoans, Hydroids, Sponges, etc.; such, however, are not to be regarded as parasites; they only attach themselves to the older spines, where the epidermis has disappeared, as they do to any other hard object. Neither can the mussels (*Montacuta*) often found among the spines of *Spatangus* and *Echinocardium* be regarded as parasites, but only as commensals. The Ostracod *Philomedes brenda* Baird (Syn. *Cypridina globosa* Lilljeborg), sometimes occurring round the anus of *Strongylocentr. dröbachiensis*, could hardly even be regarded as a commensal.

Several Echinoids play an important rôle as *food for man* in southern Europe and in tropical countries. It is only the genital organs which are eaten, raw or prepared. As food for fishes and other marine animals, the Echinoids are of less importance.

On account of their solid test the Echinoids are especially adapted for preservation in a fossil state, and they are, in fact,

among the most important and common fossils. From the Cretaceous formations of northern Europe they were during the Glacial epoch scattered over the ground through the action of the ice. Various superstitions attach to such earth-found "thunder-stones". (Cf. above, p. 9.)

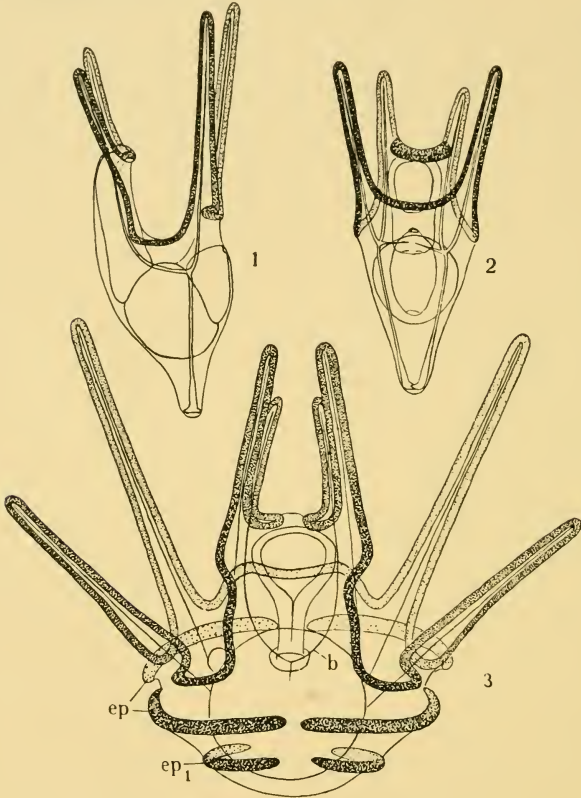


FIG. 147.—1-2. Larvæ of *Psammechinus miliaris* in the I. stage, in side view (1) and seen from the oral side (2). 3. Fully formed larva (II. stage) of *Echinus esculentus*, from the dorsal side (slightly diagrammatic). \times ca. 120. (From *Danmark's Fauna*.)

b, Dorsal arch; ep, Anterior epaulettes; ep₁, Posterior epaulettes.

Several Echinoids protect their brood; but all the littoral forms occurring in British and European seas have pelagic larvæ. These larvæ, *Echinopluteus*, are provided with a very complicated skeleton. Two larval stages may be distinguished, the I. stage, with only two pairs of arms, the postoral and antero-lateral arms, and the II. stage, with the full number of arms (Fig. 147). In the larvæ of regular Echinoids the body skeleton is partly

absorbed and transformed on the passing from the I. to the II. stage. Contrary to the Ophiuroid larvæ, in which the skeleton consists of only two symmetrical halves, the larval skeleton of the Echinoplutei consists, in the fully formed larvæ, of four paired parts, viz. (1) the body skeleton with the postoral and antero-lateral rods, and (2) the postero-dorsal rods; further, there is an unpaired rod, the dorsal arch, from which proceed the pre-oral and antero-dorsal rods. In most Echinoid larvæ (but not the *Echinus* larva) still another unpaired skeletal part, the posterior transverse rod, from which issue the rods of the postero-lateral arms, and, in Spatangoid larvæ, the unpaired posterior rod (Fig. 3, 4). When postero-lateral arms are developed, they are directed straight to the sides or obliquely backwards, never forwards, as is the case in the Ophiuroid larvæ. On the body skeleton there is often a "recurrent" rod, which, together with the body-rod, forms a sort of "basket", e.g. the larva of *Echinocyamus pusillus* (Fig. 181, 1). Some larval forms have in the II. stage peculiar "ciliated lobes" or "epaulettes". Upon the whole the Echinoid larvæ are rather complicated, but very characteristic and very beautiful organisms.

Key to the Echinoid larvæ (Echinopluteus) known from or likely to occur in British seas.

1. An unpaired process from the posterior end of the body . . . 11
 No " " " " " " " . . . 2
2. A posterior transverse rod present 3
 No " " " " " " " . . . 6
3. Postero-lateral arms well developed (Fig. 165) . . . *Arbacia lixula*
 Only short postero-lateral lobes, not developed as arms . . . 4
4. Four broad epaulettes present; postero-dorsal rod unfenestrated (Fig. 180) *Sphærechinus granularis*
 No epaulettes; both postoral and postero-dorsal rods fenestrated . 5
5. Postoral and postero-dorsal arms very long, about three times the body length, directed nearly horizontally towards the ventral and dorsal sides. Ciliated lobes very large (Joh. Müller, VII. Abhandl. Taf. V. 1-4)¹ . . . (?) *Centrostephanus longispinus*
 Postoral and postero-dorsal arms only about the length of the larval body, not ventral- and dorsalwards directed and not nearly horizontal. Ciliated lobes not so very large. (Fig. 152)² *Cidaris cidaris*

¹ In the author's *Echinodermenlarven d. Plankton Exped.*, p. 79, this larva is designated as *Echinopluteus Mülleri*. There can, however, be little doubt about its belonging to *Centrostephanus longispinus*, so that it would seem superfluous to retain the name *Echinopluteus Mülleri*.

² It would seem probable that the larva figured by Joh. Müller, VII. Abhandl. über Echinodermenlarven, Taf. I. 1-2, is also a *Cidarid* larva, and if so it could scarcely be anything but the larva of *Stylocidaris affinis*.

6. Body skeleton forms a basket structure¹
 { *Echinocyamus pusillus*
 I. stage of *Sphærechinus granularis*
 Body skeleton forms no basket structure 7
7. Postoral and postero-dorsal rods fenestrated, or, at least,
 composed of 3 parallel rods 8
 Rods all simple 9
8. Postoral and postero-dorsal rods unfenestrated, or, at most,
 fenestrated in the outer part, but composed of 3 parallel
 rods I. stage of *Arbacia lixula*
 Postoral and postero-dorsal rods fenestrated throughout their
 whole length (Fig. 183, 2) . Older larva of *Echinocyamus pusillus*
9. Posterior end of body elongate, supported by the long, more or
 less club-shaped body rods (see below)
 I. stage of *Psammechinus*, *Echinus*,
 Paracentrotus, and *Strongylocentrotus*
 Posterior end of body rounded, not elongate; body rods short,
 simple. Epaulettes present 10
10. Four epaulettes at the base of the postoral and postero-dorsal
 arms, no epaulettes at posterior-end of body (see below)
 II. stage of *Psammechinus miliaris*
 and *Paracentrotus lividus*
 Besides the four epaulettes at the base of postoral and postero-
 dorsal arms also a pair of epaulettes (or a ciliated ring) at the
 posterior end of the body (see below)
 II. stage of *Echinus esculentus*, *Ech. acutus*,
 and *Strongylocentrotus dröbachiensis*
11. Postero-lateral arms long, with skeletal rod 12
 Postero-lateral arms short, ear-shaped, without skeletal rod
 (Fig. 201) *Brissopsis lyrifera*
12. Postero-lateral rods widened at the base, the widened part
 formed by three thin lists, at an angle to each other (Joh.
 Müller, VII. Abhandl. Taf. VII.)² *Echinopluteus fusus* Mrtsn.
 Postero-lateral rods simple 13

¹ It is hardly possible to indicate how the young stage of *Sphærechinus granularis* and *Echinocyamus pusillus* can be distinguished; as soon as the postero-dorsal rod has appeared, they are easily distinguished, this rod being fenestrated in *Echinocyamus*, simple in *Sphærechinus*; further, a posterior transverse rod is never formed in *Echinocyamus*. No doubt also the (unknown) young larva of *Centrostephanus longispinus* will prove to have a basket structure.

² It is unknown to which Spatangoid this larva belongs; it is known both from the Mediterranean and the Atlantic, and may well be expected to occur also in British seas. Also in the Indo-Pacific Ocean Spatangoid larvæ with this characteristic type of postero-lateral rods occur, so that it must be assumed that several species of Spatangoids have a larva of this type.

13. Postero-lateral rods strongly thorny, especially along the posterior edge; unpaired posterior prolongation not very long, sometimes very short (Fig. 3, 4). . . . *Echinocardium cordatum*
 Postero-lateral rods only slightly thorny; unpaired posterior rods very long (Fig. 191) *Spatangus purpureus*

The young stages of the larvæ of *Psammechinus miliaris*, *Echinus esculentus*, *Ech. acutus*, and *Strongylocentrotus dröbachiensis* are very much alike, but may be distinguished by the shape of the body rods (Fig. 148). The young *Paracentrotus lividus* larva has fusiform rods like those of *Str. dröbachiensis*, only they appear to be as a rule somewhat more thorny (Fig. 176). In the second stage, the larvæ of *Psammechinus miliaris* and *Paracentrotus lividus* are easily distinguished from the *Echinus* and *Strongylocentrotus* larvæ by having only the four epaulettes



FIG. 148.—Posterior end of body rods in I. larval stage of *Psammechinus miliaris* (1), *Echinus acutus* (2), *Echinus esculentus* (3), and *Strongylocentrotus dröbachiensis* (4). \times ca. 100. 2-3, after Shearer; 1 and 4, after Th. Mortensen. (From *Danmark's Fauna*.)

at the base of the postoral and postero-dorsal arms, the latter having also a pair of epaulettes at the posterior end of the body; these posterior epaulettes are placed laterally, but often widening so as to form a nearly complete ring around the end of the body. But how the larvæ within these two groups may be distinguished from each other we cannot see in the present stage of our knowledge; especially the larvæ of *Paracentrotus lividus* and *Strongylocentrotus dröbachiensis* need a closer study.

Regarding the natural relationships of Echinoids no general agreement has yet been reached, several points being still open to discussion. The old division into the two main groups, the *Regular* (*Regularia* or *Endocyclica*) and *Irregular Echinoids* (*Irregularia* or *Exocyclica*), is no natural division, the irregular forms especially not representing a single, natural group. But for practical use the terms "regular" and "irregular" Echinoids are very convenient.

Not considering some of the old, palæozoic forms, the Echinoids may be classified in six orders, five of which are

represented in British seas ; the sixth, the *Holcypoides*, being wholly extinct.¹

*Key to the orders of Echinoids known from the British
(and European) seas.*

1. Anal opening inside the apical system ; test usually round ; gills may be present at peristomial edge ("Regularia") . . . 2
 Anal opening outside the apical system ; test usually elongate-oval ; no gills at peristomial edge ("Irregularia") . . . 3
2. Both ambulacral and interambulacral plates continuing over the peristome ; no gills at edge of peristome ; no sphæridiæ ; ambulacral plates simple I. *Cidaroidea*
 Only the ambulacral plates (generally only one pair) continuing over the peristome ; gills present at the edge of peristome ; sphæridiæ present ; ambulacral plates mostly compound II. *Diadematoidea*
3. Mouth central ; dental apparatus well developed ; test usually flattened ; tube-feet often extending also over the interambulacral areas² III. *Clypeastroidea*
 Mouth central or nearer the anterior edge of the test ; dental apparatus lacking (except in the young stages of some Cassidulids). Tube-feet confined to the ambulacra 4
4. Mouth central or anterior ; unpaired posterior interambulacral area on under side of test not different from the other interambulacral areas. Fascioles wanting IV. *Cassiduloidea*
 Mouth anterior ; unpaired posterior interambulacral area on under side of test different from the other interambulacral areas ; the first plate usually widened into a sort of lip, the following pair of plates either forming a broad "plastron" or displaced so that one plate lies behind the other (Fig. 185). Fascioles generally present V. *Spatangoidea*

I. Order. CIDAROIDEA

Shape of test regular, round, usually spherical. Anal opening in the middle of the apical area. Peristome covered by regular rows of ambulacral and interradial plates (Fig. 149). No gills and no gill-cuts at peristomial edge of test. Ambulacral plates simple, never compound. Pores of the tube-feet sometimes close together, separated only by a narrow, elevated wall, sometimes more distant, connected by a furrow ; in the latter case they are termed "conjugate". Each interambu-

¹ A supposed recent Holcypoid, *Pygastrides relictus* Lovén, seems rather to be a young Clypeastroid. Only a small, broken test known (West Indies).

² The tube-feet of the interambulacral areas usually very fine and to be seen distinctly only on microscopical examination.

lacrimal plate with only a single, large primary tubercle, surrounded by a more or less deep area, the "areole". Primary tubercles perforate, smooth or crenulate. The primary spines covered by a special outer layer, the ostracum, often set with fine, hairy, more or less anastomosing outgrowths. Only at the base of the spine the outer layer is wanting, this part being termed the "collar". Secondary spines small, usually flat, more or less strongly appressed; this especially holds good of the secondary spines surrounding the base of the primary spines, the so-called "scrobicular" spines. Teeth without keel. Only globiferous and tridentate pedicellariæ present, the former usually in two forms, the large and the small globiferous form. Sphæridia



FIG. 149.—*Cidaris cidaris*; naked test, oral side. Nat. size.

are lacking. Spicules of tube-feet small, irregular, spiny rods. Large, bush-shaped outgrowths from the upper side of the dental apparatus, the so-called Stewart's organs.

Primary spines lacking the outer layer are often found on the upper side of the test, round the apical system. These are only spines which are not yet fully formed. Here and there on the test also similar spines may be found; these are regenerating spines formed in place of spines that have been lost. Old spines are very often covered by various foreign organisms—Sponges, Bryozoa, mussels, etc. The primaries round the peristome (the oral primaries) are usually much shorter than those of the upper side of the test, and more or less specialised, sometimes curved and strongly serrate.

The globiferous pedicellariæ of Cidarids are peculiar in having the poison gland inside the valve, enclosed by the calcareous

skeleton, while in other Echinoids the poison gland hangs free on the outer side of the valve, covered only by the epidermis.

The rather numerous recent forms of this order are all regarded as belonging to only one family, while some of the, likewise very numerous, fossil forms must form separate families.

I. Family CIDARIDÆ

Same characters as those of the order. From the other families known, the palæozoic Archæocidaridæ and the cretaceous Tetracidaridæ, this family differs in having only two series of coronal plates in each interambulacrum.

Two genera are known from the British seas, but one more, *Stereocidaris* Pomel, is almost sure to be represented there also, viz. the species *Stereoc. ingolfiana* Mrtsn., which is widely distributed over the Northern Atlantic, known from off the Faroes and S. of Iceland, from off Portugal and the Cape Verdes, and, further, from the West Indies and off Florida; bathymetrical distribution ca. 300-1745 m. One more genus, *Stylocidaris* Mrtsn., may perhaps also be found there, the species *Styloc. affinis* (Philippi) (Syn. *Cidaris affinis* Philippi), which was originally known only from the Mediterranean, having been found in the East Atlantic from 33° N. down to the Cape Verdes; also known from the West Indies and off Florida. Both these species have formerly been confounded with *Cidaris cidaris*.

Key to the genera of Cidaridæ known from or likely to be represented in the British seas.

1. Surface of primary spines very finely striated, without "hairs"; collar ca. 5 mm. long, often swollen; only one sort of pedicellariæ, flat, with only two valves 2. *Poriocidaris* Mrtsn.
 Surface of primary spines with fine hairs, not finely striated; collar only ca. 1 mm. long; three kinds of pedicellariæ, large and small globiferous, and tridentate 2
2. Large globiferous pedicellariæ with a distinct end tooth 1. *Cidaris* Leske
 Large globiferous pedicellariæ without a distinct end tooth 3
3. Primary spines usually winged; test very closely covered with small tubercles; large globiferous pedicellariæ with a large elongate opening (Fig. 150, 4), stalk simple; small globiferous pedicellariæ without end tooth. (Cf. "*Ingolf*" Ech., i. p. 38, Pl. VI. 1-4, 11; Pl. XVI. 1) *Stereocidaris* Pomel

Primary spines not winged, cylindrical, tapering; test not very closely tuberculated. Large, globiferous pedicellariæ with a small opening (Fig. 150, 3), stalk with a limb of freely projecting rods. Small globiferous pedicellariæ with an end tooth. (Cf. "*Ingolf*" *Ech.*, i. p. 35, Pl. I. 1; Pl. VI. 9-10. Koehler, *Faune de France*, p. 110) . . . *Stylocidaris* Mrtsn.

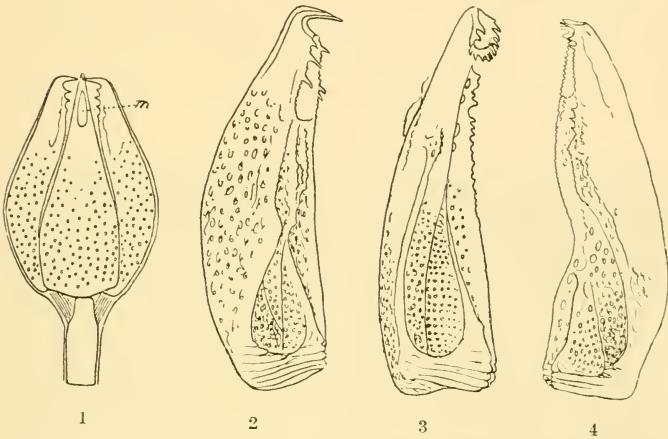


FIG. 150.—Large globiferous pedicellariæ of *Cidaris cidaris* (1-2), *Stylocidaris affinis* (3), and *Stereocidaris ingolfiana* (4). (1. From *Danmark's Fauna*; 2-4, after Th. Mortensen, "*Ingolf*" *Echinoidea*, i.)

1. A whole pedicellaria. 2-4. A single valve in side view. *m*, The opening of the poison gland, which lies within the valve. 1. $\times 33$; 2 $\times 50$; 3 $\times 80$; 4 $\times 65$.

1. *Cidaris* Leske.

(Syn. *Dorocidaris* A. Agassiz.)

Primary tubercles smooth, not crenulate; ambulacral pores not conjugate. Primary spines with more or less thorny longitudinal ridges, the surface between the ridges covered with fine, branching, anastomosing hairs. Collar short, only ca. 1 mm. long. Oral primaries not strongly serrate. All three kinds of pedicellariæ present; both large and small globiferous with a well-developed end tooth (Fig. 150, 1-2); the stalk of the large globiferous form very short, without a limb.

Only one species known from the British seas (and the N.E. Atlantic).

1. *Cidaris cidaris* (Linnæus). (Figs. 149, 150, 1-2, 151.)

(Syn. *Echinus cidaris* Linnæus; *Cidaris papillata* Leske, *Cidaris hystrix* Lamk.; *Dorocidaris papillata* (Leske) A. Agassiz.)

Primary tubercles not crenulate. Ambulacral areas with four regular series of tubercles (at least in the larger specimens). Apical system large, about half the horizontal diameter of the test; oculars may be partly in contact with the periproct. Genital pores not very large. Primary spines slender, about

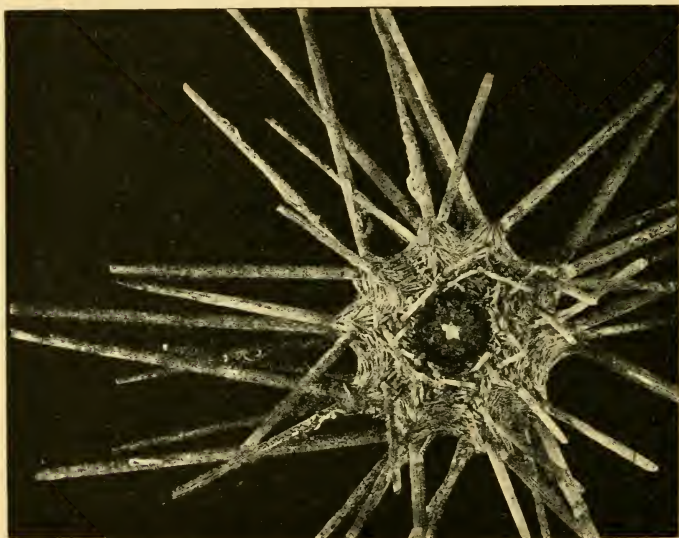


FIG. 151.—*Cidaris cidaris*; from the oral side. Somewhat diminished. (After Koehler, *Echinod. Faune de France*.)

twice the diameter of the test. Colour in life yellowish or greyish-white. The collar of the primary spines of a faint pinkish tint. Reaches a considerable size, up to ca. 65 mm. horizontal diameter of test.

It lives on all sorts of bottom; is often brought up on the hooks of the fishermen. The *larva* (Fig. 152) is a typical Echinopluteus with a posterior transverse rod, but no postero-lateral arms. Postoral and postero-dorsal rods fenestrated.

In British seas this species is very common along the west coast of Ireland and in the Faroe Channel, in ca. 150-ca. 1250 m. (it is recorded from both the Rockall and the Lousy Bank). It

is elsewhere distributed from off Bodö on the Norwegian coast to

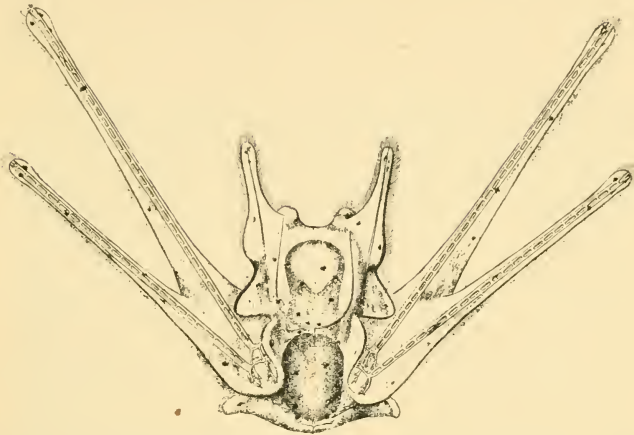


FIG. 152.—Larva of *Cidaris cidaris*; from the dorsal side. $\times 62$.
(After Prouho, *Rech. s.l. Dorocidaris papillata*.)

the Azores, the Cape Verdes, and the Mediterranean. Also known from off St. Paul's Rock; the numerous records of its occurrence in the West Indies and in the Indo-Pacific are due to confusion with other species. Bathymetrical distribution ca. 50-1800 m.

2. *Poriocidaris* Mrtsn.

Primary tubercles on upper side of test distinctly crenulate; ambulacral pores not conjugate. Primary spines with a few more or less thorny ridges, the surface otherwise very finely striated, but without hairs. Oral primaries strongly serrate. Collar of primary spines very long, ca. 5-7 mm., often swollen. Only one sort of pedicellariæ, a large, flat, bivalve form (Fig. 153).

This genus has hitherto generally been designated as *Porocidaris*, but erroneously, the true *Porocidaris* Desor being a fossil (Eocene) form, characterised by having a circle of pore-like depressions in the areoles, and conjugate pores; none of

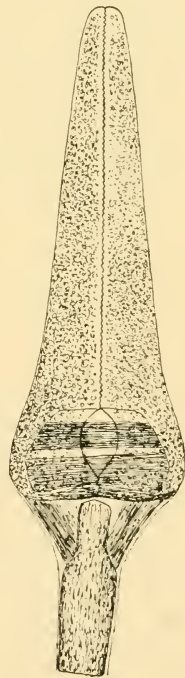


FIG. 153.—Bivalve pedicellaria of *Poriocidaris purpurata*. $\times 33$.

the various recent forms described as *Porocidaris* species have any nearer relation to the fossil *Porocidaris*. The genus *Porocidaris* is very nearly related to the genus *Histocidaris* Mrtsn., and may perhaps not deserve to rank higher than as a subgenus of *Histocidaris*, from which it differs only in its peculiar bivalve pedicellariæ (in *Histocidaris* they are usually three-valved, but in one species also bivalve pedicellariæ occur) and in the unusually long collar of the primary spines.

Only one species in the British seas, the only species known.

1. *Porocidaris purpurata* (Wyv. Thomson). (Fig. 154.)

(Syn. *Porocidaris purpurata* Wyv. Thomson ; *Cidaris purpurata* (Wyv. Thoms.) Bell ; *Histocidaris purpurata* (Wyv. Thoms.) H. L. Clark ; *Porocidaris gracilis* Sladen.)

Ambulacral areas rather closely tuberculated, the tubercles forming, however, four fairly distinct longitudinal series. Apical system about half the horizontal diameter of the test ; oculars sometimes partly in contact with the periproct. Female genital pores very large, may even break through the outer edge of the genital plate. Primary spines slender, with more or less numerous rather coarse thorns ; they are about twice as long as the diameter of the test. In adult specimens the upper spines are much shorter, very pointed, their collar often very long and more or less swollen.¹ Colour in life brownish-violet ; especially the collar of the primary spines usually of a dark purplish-violet colour, which forms a striking contrast to the white or pale pink outer part of the spine. Reaches a size of ca. 50 mm. diameter of test.

Development unknown, but the large size of the eggs and genital openings indicate that it has direct development, without a pelagic larva. There are no observations to support the suggestion that it might protect its brood. It lives on muddy bottom.

This very beautiful species was first discovered north of the Hebrides ("Porcupine") ; it has since been found several times off S.W. Ireland ("Helga"), in depths of ca. 1000-1400 m. It

¹ A form with the collar of the primary spines unusually swollen was designated by the author ("*Ingolf*" *Ech.*, i.) as a separate variety, the var. *talismani*. There is, however, no reason to maintain this variety, as all degrees of swollen collars may be found. The *Porocidaris gracilis* of Sladen is only the young *P. purpurata*.

is further known from S.W. of Iceland, the Bay of Biscay, and off the Canaries. Bathymetrical distribution ca. 750-1800 m.

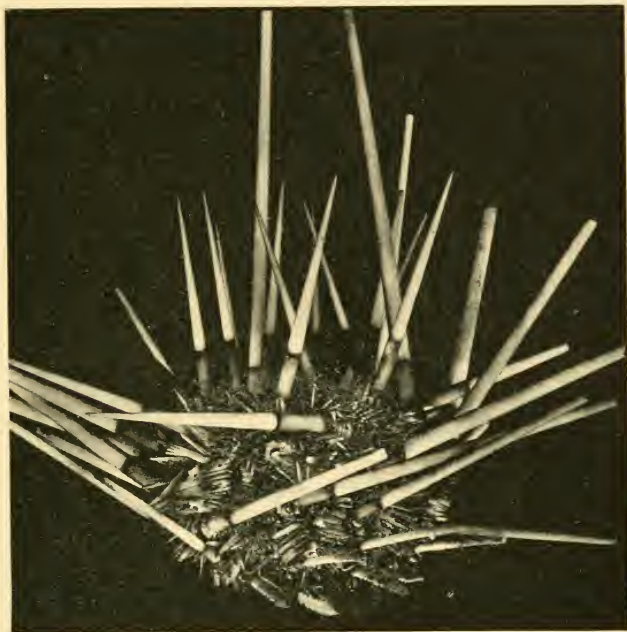


FIG. 154.—*Poriodicidaris purpurata*. Somewhat reduced

It has also been recorded from the Indian Ocean, but only a single, very young specimen. It is scarcely probable that it is really the same species.

II. Order. DIADEMATOIDEA

(Syn. *Centrechinoidea*.)

Shape of the test regular, round, spherical or flattened. Anal opening in the middle of the apical area. Peristome with one pair or a series of plates in each radius, while the interambulacral plates never form regular series over the peristome. Gills and, usually, gill-cuts present at the peristomial edge of test. Ambulacral plates mostly compound, more rarely simple. Usually both ambulacral and interambulacral plates with a primary tubercle (spine), and often some of the secondary tubercles (spines) grow to the same size as the primary and form regular vertical or horizontal series. Primary tubercles perforate or imperforate, crenulate or smooth. Primary spines only exceptionally with a

special outer layer, never with fine, anastomosing hairs. Secondary spines usually of the same shape as the primaries. Teeth with or without keel. Mostly four sorts of pedicellariæ present, globiferous, tridentate, ophicephalous, and triphyllous. Sphæridia present. Spicules of tube-feet irregular or C-shaped.

This great order, which comprises all the numerous recent and fossil regular Echinoids, excepting the Cidarids, is divided into three suborders, characterised mainly by the characters of the dental apparatus and of the compound ambulacral plates. Two of these suborders are represented in the British seas, and the third no doubt will be found also, though not yet actually known from there.

Key to the suborders of the Diadematoidea.

1. Teeth without a keel on the inside; the epiphyses of the dental apparatus not joining above the teeth (Fig. 146, 2). In the compound ambulacral plates the lowermost primary plate but one is the largest (Fig. 155, 1). Tubercles perforate and crenulate I. *Aulodonta*
- Teeth with a keel on the inside. Tubercles not perforate . . . 2
2. Epiphyses of the dental apparatus not joining above the teeth. In the compound ambulacral plates the lowermost primary plate but one is the largest II. *Stirodonta*
- Epiphyses joining so as to form an arc above the teeth (Fig. 146, 1). In the compound ambulacral plates the lowermost primary plate is the largest (Fig. 155, 2) III. *Camarodonta*

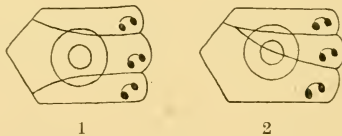


FIG. 155.—Compound ambulacral plates. (From *Danmark's Fauna*.)

1. The Diadematoïd type, the middle or, in polyporous plates, the lowermost primary plate but one being the largest. 2. The Echinoid type, the lowermost primary plate being the largest. Diagrammatic.

I. Suborder. *AULODONTA* Jackson.

Test usually rather thin, sometimes flexible. Compound ambulacral plates of the Diadematoïd type, the middle or, in the polyporous forms, the lowermost primary plate but one being the largest. Primary spines without an outer layer, usually long and fragile, hollow, mostly finely spiny, the spinules being more or less distinctly arranged in spirals. Tubercles perforate and mostly crenulate. Teeth concave, without a keel on the inside, the epiphyses on the pyramids not joining above the teeth.

One family, the *Echinothuridæ*, is represented in the British seas, but three more are, more or less, likely to occur there also, viz. the *Diadematidæ*, *Aspidodiadematidæ*, and *Pedinidæ*. Of the family *Diadematidæ* the genus *Centrostephanus* Peters is represented by the species *C. longispinus* (Philippi) at the Azores and Canaries and in the Mediterranean; it is mainly a sublittoral form, occurring in depths of ca. 50-200 m. There is perhaps a possibility of its occurring in the deeper sublittoral off S.W. Ireland. The genus *Diadema* Gray, represented at Madeira and the Canaries by the species *D. antillarum* Philippi, cannot be expected to occur as far north as the British area, being a strictly littoral form. Of the family *Aspidodiadematidæ*, the genus *Plesiodiadema* Pomel (Syn. *Dermatodiadema* A. Agassiz), namely the species *Pl. antillarum* (A. Agassiz), has been found south of the Canaries, 2500 m. ("Valdivia"); some unidentifiable fragments of a *Plesiodiadema* were taken by "Hirondelle II." at 30° 50' N., 25° 43' W., 5300 m. The species *Pl. antillarum* is elsewhere known from the West Indies, 280-2860 m. It is perhaps not unlikely that the other West Indian *Aspidodiadematid*, *Aspidodiadema Jacobyi* A. Agassiz (ca. 170-515 m.), also will prove to occur in the N.E. Atlantic.

The family *Pedinidæ* is represented in the N.E. Atlantic by the genus *Cænopedina* A. Agassiz, the species *C. cubensis* A. Agassiz (Syn. *Hemipedina cubensis* (A. Agassiz)) having been found off the Azores and Canaries, 1098-1187 m. ("Princesse Alice"); the species is elsewhere known from the West Indies, ca. 250-485 m.

The main characters of these three families are given in the following key. For a description of the species in question reference may be made to Koehler's *Faune de France: Échino-dermes*, p. 112 (*Centrostephanus longispinus*); *Monaco. Fasc.*, xxxiv., p. 221; Pls. I., XXX., XXXI. (*Cænopedina cubensis*); and A. Agassiz: "Blake" *Echini*, p. 25, 27, Pls. IX., IX.A (*Plesiodiadema antillarum*, *Aspidodiadema Jacobyi*). The genera *Plesiodiadema* and *Aspidodiadema* are distinguished by the latter having some large primary tubercles in the ambulacra, while in the former all the ambulacral tubercles are small.

Key to the families of the Aulodonta known from or likely to be represented in the British seas.

1. Only one pair of ambulacral plates on the peristome in each radius, the peristome otherwise naked or with irregularly arranged small plates; test not soft or flexible 2
- A series of ambulacral plates on the peristome in each radius, the peristome being completely covered by the ambulacral plates; test more or less soft, flexible I. *Echinothuridæ*

2. Tubercles crenulate ; ocular plates more or less broadly in contact with the periproct 3
 Tubercles smooth ; ocular plates excluded from the periproct

Pedinidæ

3. Genital and ocular plates of almost equal size and shape, forming a very conspicuous ring round the periproct. Only a single large tubercle on each interambulacral plate. Test high ; spines very long and slender, usually curved

Aspidodiadematidæ

Genital and ocular plates not of equal size and shape ; several large tubercles at least on the interambulacral plates at the ambitus of test. Shape of test usually somewhat flattened ; spines usually very long, but not curved . . . *Diadematidæ*

I. Family ECHINOTHURIDÆ

Test flattened, usually soft and flexible, on account of the fact that the coronal plates are imbricated ; the imbrication is different in the two areas, the plates of the interambulacral areas overlapping from the mouth towards the apex, the ambulacral plates in the opposite direction. The peristome wholly covered by the ambulacral plates, which continue in an uninterrupted series to the very edge of the mouth. The gills are very small ; no gill-cuts in the peristomial edge of the test. Primary spines on the oral side of test club-shaped or tipped with a white hoof. Miliary spines usually provided with poison glands. Polian vesicles usually well developed.

The Echinothurids are chiefly deep-sea forms, often gorgeously coloured ; in the Indo-Pacific also some littoral forms are found. Some of them reach a very large size, up to more than 300 mm. diameter of test, the largest of all known Echinoids. When being dried without special preservation these forms will generally collapse completely and become quite flat. Also they are liable to be more or less distorted by the rough handling in the trawl, and especially the large primary spines with the characteristic terminal hoof are very often broken, so that it may be difficult enough to find even a very few of them intact. The poison spines sting very painfully. Development unknown, but judging from the large size of the eggs the deep-sea forms at least must have a direct development, without a pelagic larval stage.

Four genera are known from the British seas (and the N.E. Atlantic).

*Key to the genera of Echinothuridæ known from the British seas
(and the N.E. Atlantic).*

1. Primary spines of oral side club-shaped, enclosed in a rather thick bag of skin 1. *Phormosoma* Wyv. Th.
Primary spines of oral side ending in a white hoof 2
2. Tube-feet on oral side arranged in a single, more or less irregular series (Fig. 156, 2) 3. *Hygrosoma* Mrtsn.
Tube-feet on oral side arranged in three series 3
3. The larger primary plate in each compound ambulacral plate divided in two parts, each compound ambulacral plate thus composed of 4 plates, one of them without pores; all the pore plates of about equal size (Fig. 156, 3) 4. *Sperosoma* Koehler
Each compound ambulacral plate consists of 3 plates only, the large, undivided middle plate and two very small plates enclosed between the larger primaries, not reaching the edge of the area (Fig. 156, 1) 2. *Aræosoma* Mrtsn.

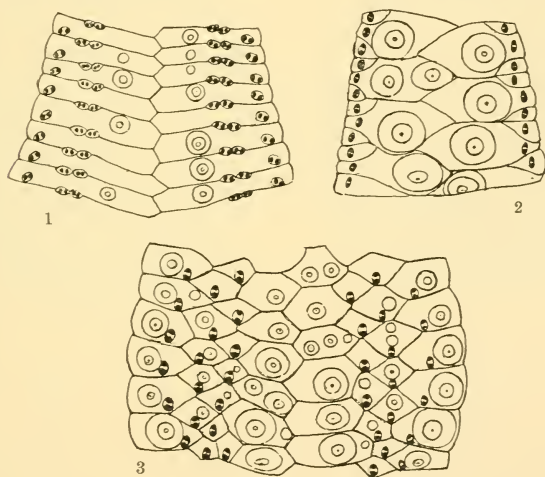


FIG 156.—Part of ambulacra of *Aræosoma hystrix* (1), *Hygrosoma Petersii* (2), and *Sperosoma Grimaldii* (3). Slightly diagrammatic.

1. **Phormosoma** Wyv. Thomson.

Test rather rigid, flat below, gently arched on the upper side. Oral side with numerous large tubercles (areoles) and spines, the upper with only few of them, and much smaller ones, which gives the two sides a very different aspect. Edge of disk rather sharp. Tube-feet arranged in a single series on the oral side. Primary spines on oral side club-shaped, enclosed in a rather thick bag of skin. Only tridentate and triphyllous pedicellariæ.

Only one species known from the British seas (and the N.E. Atlantic).

1. *Phormosoma placenta* Wyv. Thomson. (Fig. 157.)

On the oral side of test each interambulacral plate carries 2-3 very large and deep areoles, occupying nearly the whole plate; the ambulacral plates carry only one such large areole each. The tubercles small in comparison with their large areoles; it is the spines attached to these tubercles and areoles which are club-shaped, clad in a bag of skin. Along the edge of the test there is a more or less marked fringe of smaller, close-set spines. The aboral side of the test is sparsely covered with spines, the

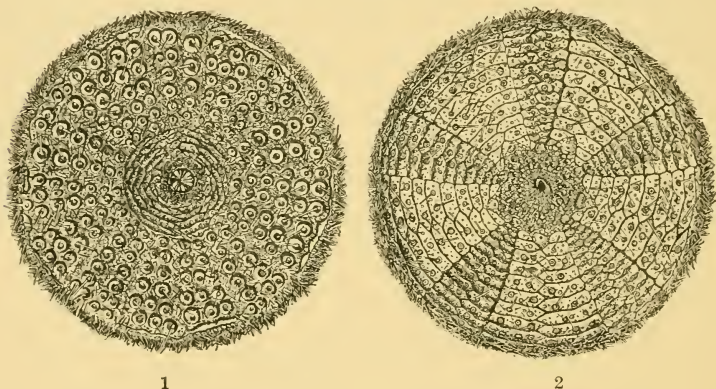


FIG. 157.—*Phormosoma placenta*; oral (1) and dorsal side (2). About half size. (After Wyv. Thomson, "*Porcupine*" *Ech.*)

tubercles not surrounded by large areoles, and the spines not club-shaped, nor enclosed in a skin-bag. Tridentate pedicellariæ simple, leaf-shaped. Colour in life appears to be purplish below, grey above, flecked with purple; preserved specimens usually yellowish-brown. Reaches a size of ca. 125 mm. diameter of test.

In British seas this easily recognisable species is very common off the west coast of Ireland, in depths of ca. 600-1800 m.; also in the warm area of the Faroe Channel. It is distributed from south of Iceland to the Gulf of Guinea, and also from the Davis Strait to the West Indies. Bathymetrical distribution ca. 275-2500 m.

2. *Aræosoma* Mrtsn.(Syn. *Calveria* Wyv. Thomson.)

Test very flexible ; no sharp limit between oral and aboral side ; the aspect of the two sides not very different. Ambulacral plates consisting of a large primary plate which is simple, not divided into an inner and an outer plate, and two very small plates lying between the larger plates, far from the edge (Fig. 156, 1). Tube-feet in three dense series. Primary spines on oral side curved, ending in a small white hoof. Tridentate pedicellariæ with the valves more or less involute (Fig. 158) ; besides the tridentate and triphyllous pedicellariæ a third sort, with four valves, the "tetradactylous" form (Fig. 160), may occur.

Two species are known from the British seas (and the N.E. Atlantic).

*Key to the species of Aræosoma known from the British
(and European) seas.*

Colour of test bright red ; terminal part of large, involuted pedicellariæ with more or less irregular, never deeply sinuate, edge (Fig. 158, 2). No tetradactylous pedicellariæ

1. *A. hystrix* (Wyv. Thoms.)

Colour of test brownish or violet ; terminal part of large involuted pedicellariæ with deeply sinuate edge (Fig. 158, 3) ; tetradactylous pedicellariæ may occur 2. *A. fenestratum* (Wyv. Thoms.)

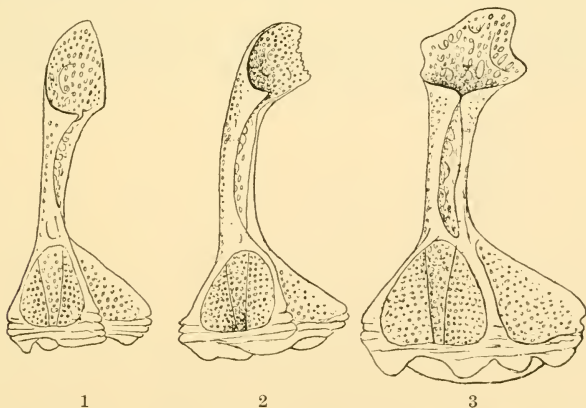


FIG. 158.—Valves of tridentate pedicellariæ of *Hygrosoma Petersii* (1), *Aræosoma hystrix* (2), and *Aræosoma fenestratum* (3), 1×65 ; $2-3 \times 75$. (After Th. Mortensen, "Ingolf" Echin., i.)

1. *Aræosoma hystrix* (Wyv. Thomson). (Fig. 159.)

(Syn. *Calveria hystrix* Wyv. Thomson ; *Asthenosoma hystrix* (Wyv. Thomson).)

A regular series of large tubercles along the outer (adradial) edges of the interambulacra, and another, somewhat less regular, series along the middle of the interambulacral plates. Irregular series of similar large tubercles in the ambulacra. The plates of

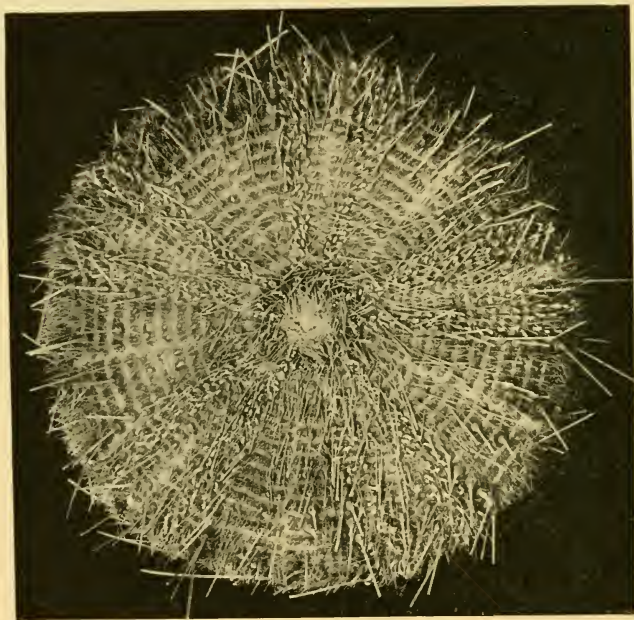


FIG. 159.—*Aræosoma hystrix*; oral side. Slightly reduced.

both areas generally not restricted in the middle, leaving no distinct membranous spaces between them. The large tridentate pedicellariæ (Fig. 158, 2) with the valves much involute, the small widened terminal part with straight, more or less irregularly serrate edges ; they reach a size of ca. 1.2 mm. length of head. Also smaller tridentate pedicellariæ occur, with the involuted part of the valve shorter and the widened terminal part correspondingly larger. No tetradactylous pedicellariæ. Colour in life a bright red or claret colour, which keeps very well in alcohol and also in dried specimens ; even the denuded test retains the red colour. Reaches a size of ca. 240 mm. in horizontal diameter.

This splendid species, one of the great discoveries of the "Porcupine", appears to be common in the warm area of the Faroe Channel and off the west coast of Ireland; it is a characteristic inhabitant especially of the ooze between ca. 900-1200 m. It is elsewhere distributed from off S.W. Iceland to the Bay of Biscay, the Azores, and the Canary Islands. Bathymetrical distribution ca. 360-1525 m.

2. *Aræosoma fenestratum* (Wyv. Thomson). (Fig. 160.)

(Syn. *Calveria fenestrata* Wyv. Thoms.; *Asthenosoma fenestratum* (Wyv. Thoms.), *Aræosoma violaceum* Mrtsn.)

In general arrangement of tubercles and spines resembling the preceding species very much; but usually the plates are restricted in the middle, leaving a more or less conspicuous membranous space between them. The large tridentate pedicellariæ (Fig. 158, 3) have the edge of the outer, widened part of the valves deeply sinuate; they are very conspicuous, up to 2 mm. length of head. Smaller forms are found in considerable numbers, with the involuted part shorter and the widened part correspondingly larger, till, in the smallest ones, the valves become simply leaf-shaped. The tetradactylous pedicellariæ (Fig. 160) are of relatively rare occurrence and rarely found intact. Colour brownish or purplish-violet or pale mauve, keeping fairly well in alcohol and also in dried specimens. Reaches a larger size than *A. hystrix*, up to ca. 280 mm. horizontal diameter of test.

The shape of the large tridentate pedicellariæ and the general colour are the most reliable characters distinguishing this species from *A. hystrix*.

In British seas this species has been recorded from off the



FIG. 160. — Tetradactylous pedicellaria of *Aræosoma fenestratum*. $\times 24$. (After Wyv. Thomson, "Porcupine" Echinoidea.)

west coast of Ireland, from off Arran Islands, and off Rockall.¹ In places it occurs in very great numbers, and, upon the whole, appears to be rather common, occurring in depths of ca. 500-900 m. It is elsewhere distributed from the Denmark strait to off the Portugal coast, and on the American side at least down to the Florida coast. Bathymetrical distribution ca. 145-900 m.

3. *Hygrosoma* Mrtsn.

(Syn. *Echinosoma* Pomel.²)

Test very flexible; no sharp limit between oral and aboral side, the aspect of the two sides not very different. Ambulacra consisting of a large primary plate which is simple, not divided into an inner and an outer plate, and of two much smaller plates lying close to the edge of the area (Fig. 156, 2). Tube-feet on the oral side in a single series, on the aboral side in three close series. Primary spines of oral side ending in a large, white hoof. Tridentate pedicellariæ with involute or simply leaf-shaped valves. No tetradactylous pedicellariæ; ophicephalous pedicellariæ may occur.

Two species have been recorded from the British seas (and the N.E. Atlantic).

*Key to the species of Hygrosoma known from the British
(and European) seas.*

Valves of tridentate pedicellariæ strongly involute, more or less curved 1. *H. Petersii* (A. Agass.)

Valves of tridentate pedicellariæ simply leaf-shaped
H. uranus (Wyv. Th.)

1. *Hygrosoma Petersii* (A. Agassiz). (Fig. 161.)

(Syn. *Phormosoma Petersii* A. Agass.; *Ph. luculentum* Koehler, W. de Morgan, non A. Agassiz; *Phormosoma uranus* Koehler, Bell, non Wyv. Thomson; *Echinosoma Petersii* (A. Agass.).)

Large tubercles of the oral side only on the outer 5-6 plates, arranged in rather irregular series, two in the ambulacral, four in the interambulacral areas. On the aboral side the tubercles quite irregularly arranged. No membranous spaces between the

¹ The locality "North Sea" given for this species in H. L. Clark's *Catalogue of the Recent Sea-urchins of the British Museum* must rest on an error in the labelling. No Echinothurid occurs in the North Sea.

² The name *Echinosoma* cannot be used for this genus, being pre-occupied several times over.

plates. The large, hoofed primary spines of the oral side scarcely curved. Tridentate pedicellariæ of one sort only, but of various sizes, up to 1 mm. length of head, with valves curved and much involuted (Fig. 158, 1); also ophicephalous pedicellariæ are occasionally found. Colour in life a deep claret or violet colour, which keeps fairly well in alcohol. Reaches a size of nearly 200 mm. horizontal diameter.

In this species the remarkable parasitic Copepod *Pionodes-*

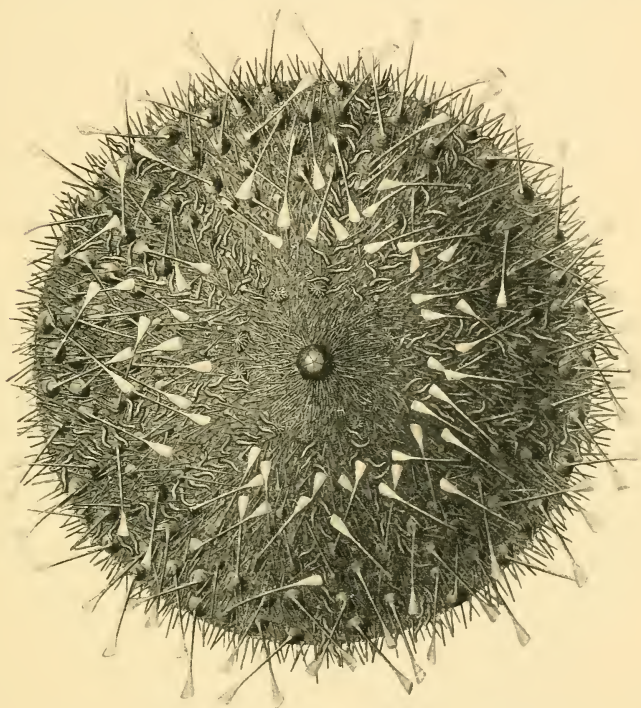


FIG. 161.—*Hygrosoma Petersii*; oral side. Diminished.
(After Koehler, *Monaco*, xii.)

modes phormosomæ occurs, producing large galls on the inside of the test.

In British seas this species has been found off S.W. Ireland (50° 29' N., 11° 48' W.), in a depth of 1800 m. ("Flying Fox"). No doubt it will be found to have a wider distribution in the deep sea off the British Islands. It is elsewhere known from the Bay of Biscay, off the Moroccan coasts, and the Azores; further from the east coast of N. America and the West Indies. Bathymetrical distribution, 730-2870 m.

[*Hygrosoma uranus* (Wyv. Thomson).]

(Syn. *Phormosoma uranus* Wyv. Thoms., *Echinostoma uranus* (Wyv. Thoms.).)

This species appears to be in general very like the preceding ; but as it has never been duly described, it is not known whether

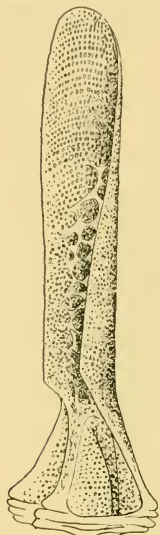


FIG. 162. — Valve of tridentate pedicellaria of *Hygrosoma uranus*.
× 33

perhaps specific differences are found in the arrangement of the tubercles. The only character known with certainty to distinguish it from *H. Petersii* is the shape of the tridentate pedicellariæ, which have simply leaf-shaped valves (Fig. 162), differing thus very markedly from the highly involute pedicellariæ of *H. Petersii*. Colour in life unknown. Reaches apparently as large a size as *H. Petersii*.

From British seas this species has been recorded from N.W. of Lewis, 1000 m. ("Knight Errant"), and from 51° 1' N., 11° 50' W., 1350 m. (Sladen). Both these records are, however, erroneous. The former specimen is *Sperosoma Grimaldii*, the latter *Phormosoma placenta*.¹ The true *H. uranus* is known only from off the Portugal coast, 3145 m. ("Challenger"), and off the Saharan coast, 938 m. ("Talisman").

4. *Sperosoma* Koehler.

Test very flexible ; no sharp limit between oral and aboral side, the aspect of the two sides not very different. Large primary plates of the ambulacra divided into an outer, poriferous and an inner, non-poriferous part (Fig. 156, 3) ; the smaller primary plates of the ambulacra being rather large, the ambulacra thus, in fact, are composed of 8 series of plates instead of the usual 2 series. In correspondance herewith the ambulacra, especially on the oral side, are very broad, as broad as or even broader than the interambulacra (while in the other genera the ambulacra are distinctly narrower than the interambulacra). No

¹ The two specimens in question were sent to the author for re-examination by the authorities of the British Museum and the Irish National Museum.

membranous spaces between the plates. Tube-feet on the oral side in 3 series. Primary spines of oral side ending in a large hoof. Tridentate pedicellariæ with leaf-shaped, not involute, valves. Ophicephalous pedicellariæ may occur.

One species known from the British seas, and from the Atlantic in general.

1. *Sperosoma Grimaldii* Koehler. (Fig. 163.)

Large tubercles of the oral side only on the outer 4.5 plates, rather irregularly disposed. The large, hoofed primary spines

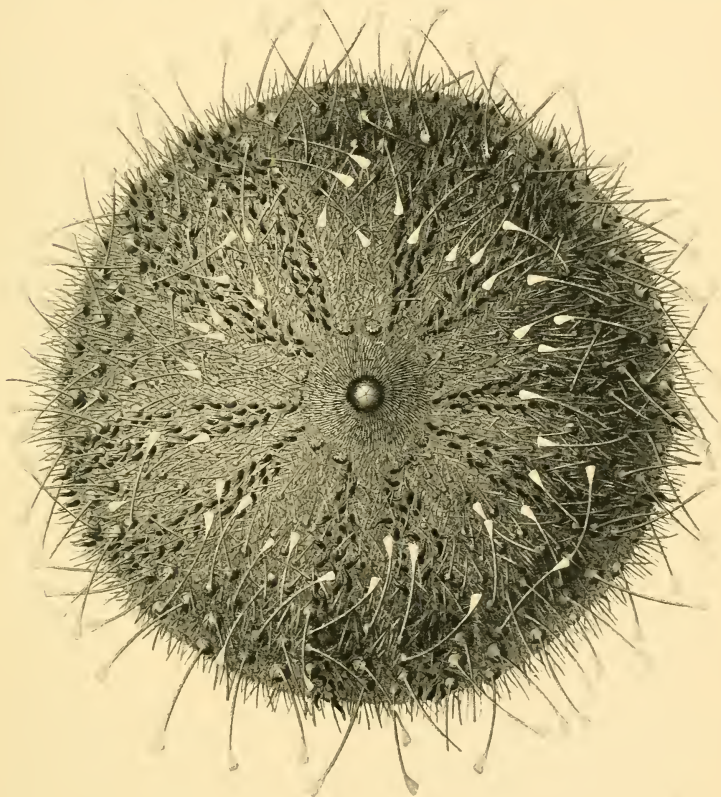


FIG. 163.—*Sperosoma Grimaldii*, oral side. Reduced.
(After Koehler, "Monaco", xii.)

distinctly curved. Large tridentate pedicellariæ up to 2 mm. length of head; the valves are simply leaf-shaped, the outer part of the valves filled up by a spiny meshwork. Ophicephalous pedicellariæ have not been observed in this species. Colour in

life a beautiful violet or purple, the colour not keeping very well in alcohol. Grows to a size of at least 220 mm. horizontal diameter.

In British seas this species has been found in the Faroe Channel, warm area ($59^{\circ} 28' \text{ N.}$, $8^{\circ} 1' \text{ W.}$, 1100-1300 m., "Michael Sars"), and off S.W. Ireland ($51^{\circ} 15' \text{ N.}$, $11^{\circ} 47' \text{ W.}$, ca. 1275 m., "Helga"). It is elsewhere known from south of Iceland to the Azores and Cape Verde, and is also recorded from the West Indies. Bathymetrical distribution ca. 300-2300 m.

[II. Suborder. STIRODONTA Jackson.]

Test usually very compact, never flexible. Ambulacral plates simple or, when compound, of the Diadematoïd type (Fig. 155, 1), or only consisting of two primary plates. Primary spines usually strong, not hollow, with an outer layer, which may, however, be reduced to a small cap, found only on the oral primaries. Tubercles imperforate (in the recent forms), crenulate or smooth. Teeth with a keel on the inside; epiphyses of the tooth pyramids not joining above the teeth (Fig. 146, 2). Only tridentate and ophicephalous pedicellariæ present.

No family of this suborder is known from the British seas, but one of them, the Saleniidæ, may be expected almost with certainty to occur there, and another, the Arbaciidæ, may perhaps also prove to be represented there.

Key to the families of the Stirodonta likely to be represented in British seas.

Primary spines long and slender, usually thorny, with a well-developed outer layer; only one on each interambulacral plate. Secondary spines flat, appressed. Tubercles crenulate. Ambulacral plates simple or only composed of two primary plates; pores in a single series. A large, angular plate, the "suranal" plate, on the periproct Fam. *Saleniidæ*

Primary spines usually short and stout, smooth, exceptionally (*Coelopleurus*) long, slender, curved. Tubercles non-crenulate. Outer layer of primary spines usually (excepting *Coelopleurus*) reduced to a small cap on the oral primaries; one or more primary spines (tubercles) on each interambulacral plate. Secondary spines not flat, appressed. Ambulacral plates composed of three, rarely more, primary plates; pores in three series. Periproct covered by 4, rarely 5, symmetric valves

Fam. *Arbaciidæ*.

Fam. SALENIIDÆ

Diagnosis of the family given in the key.

This family, which was very flourishing during the Jurassic and Cretaceous periods, has but few living representatives. These latter have been divided into two genera, namely *Salenia* Gray, with ambulacral plates compound, made up of two primary plates, and *Salenocidaris* A. Agassiz, with ambulacral plates simple, excepting one or two at the peristome.

Of the genus *Salenia*, thus restricted, no species have been found in the N.E. Atlantic, but one, *S. Pattersoni* A. Agassiz, occurs in the West Indies and might perhaps also be found in the N.E. Atlantic; it is easily recognisable by its primaries, which are banded with red and white.¹ Of the genus *Salenocidaris*, two species have been found in the N.E. Atlantic, viz. *S. profund*i (Duncan) (Syn. *Salenia hastigera* A. Agassiz), known from the Faroe-Iceland banks (63° 9' N., 13° 27' W., 880 m., "Michael Sars"), from the Bay of Biscay and the Azores to Tristan d'Acunha, and also recorded from various places in the Indo-Pacific; bathymetrical distribution, ca 180-3380 m.; *S. varispina* (A. Agassiz), found off the Azores, 1800-3015 m. ("Challenger"), also recorded from the West Indies and off Ascension; bathymetrical distribution, 630-3015 m. These two species are thus distinguished:

Usually 5 (3-6) larger ambulacral tubercles in each series on the oral side. Valves of tridentate pedicellariæ strongly curved, indented near tip; test rarely exceeding 10 mm. horizontal diameter *S. varispina* (A. Agass.)

Usually 3 (2-4) larger ambulacral tubercles in each series on the oral side; valves of tridentate pedicellariæ nearly straight; up to 16 mm. horizontal diameter of test *S. profund*i (Duncan)

The species *Salenocidaris profund*i (Fig. 164), occurring both to the north and the south of the British area, may be expected almost with certainty to occur also off the west coast of Ireland and Scotland.

Nothing is known about the biology and development of the

¹ Another species with similar red-banded spines, *S. phoinissa* A. Agass. and H. L. Clark, occurs off S. Africa. For the characters distinguishing these species see A. Agassiz and H. L. Clark, *Hawaiian, a.o. Pacific Echin. Salenidæ . . . Diadematiidæ*, p. 54

Saleniidæ. All Saleniids are small forms and all are inhabitants of the deep sea.

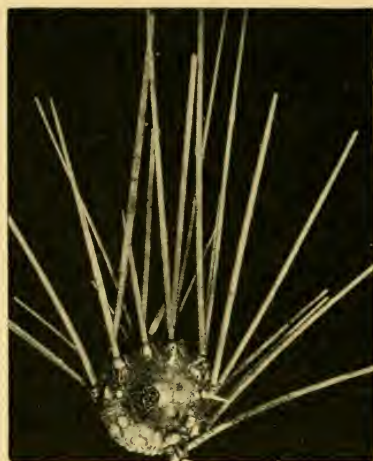


FIG. 164.—*Salenocidaris profundis*, dorsal side; half denuded. Nat. size.
(After Döderlein, *Echinoidea*, *Deutsche Tiefsee Exped.*)

Fam. ARBACIIDÆ

Diagnosis of the family given in the key.

In European seas this family is represented only by the genus *Arbacia* Gray (Syn. *Echinocidaris* Desmoulins), and only by the species *A. lixula* (Linn.) (Syn. *Arb. pustulosa* (Leske), *æquituberculata* (Blainville)), which occurs in the Mediterranean, off the Moroccan coasts and at the Azores, but is not known to the north of the Gibraltar Strait. It is mainly a littoral form. Another genus, *Arbaciella* Mrtsn., with only known species *Arb. elegans* Mrtsn., a very small form with flattened spines, occurs on the African west coast, but is not known to the north of Cape Blanc. There is scarcely any probability of these two species occurring as far north as the British area.

In the West Indies are found three deep-sea forms of Arbaciids, namely *Coelopleurus floridana* A. Agassiz, a large form with very long curved and pointed, red primary spines, *Podocidaris sculpta* A. Agassiz, and *Habrocidaris scutata* (A. Agassiz), the two latter very small forms, of white colour, the former with 4, the latter with 5, anal plates. Although not hitherto known outside the West Indies, it is not improbable that they may occur also in the N.E. Atlantic deep-sea region.

The *Arbacia* larva is very characteristic owing to its long, obliquely posteriorly directed postero-lateral arms (Fig. 165).

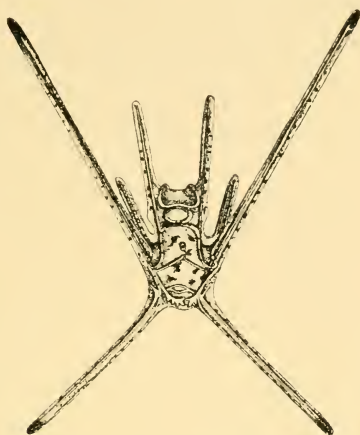


FIG. 165.—Larva of *Arbacia lixula*. (After Joh. Müller, VII. Abhandl. über Echinod. larven.)

III. Suborder. CAMARODONTA Jackson.

Test compact, never flexible. Ambulacral plates compound, of the Echinoid type (Fig. 155, 2), the lowermost primary plate being the largest. Primary spines without an outer layer, usually not very long, smooth, not hollow. Tubercles imperforate, crenulate or smooth. Teeth with a keel on the inside; the epiphyses of the dental pyramids join above the teeth (Fig. 146, 1). Usually 4 kinds of pedicellariæ, globiferous, tridentate, triphyllous, and ophicephalous. Spicules of tube-feet usually regular, C-shaped.

This suborder is divided into several families, three of which are represented in the British seas, while a fourth, the *Temnopleuridæ*, may be expected to occur there also, though as yet not known from there.

Key to the families of Camarodonta known from or likely to be represented in the British seas.

1. Test usually with grooves in the horizontal sutures or on the interambulacral plates, especially at the primary tubercles, which are crenulate or smooth Fam. *Temnopleuridæ*
 Test without grooves; tubercles smooth 2
2. Gill-cuts at edge of peristome sharp and deep; globiferous pedicellariæ without side teeth on the valves; usually with mucous glands on the stalk and with dumbbell-shaped spicules in the skin II. Fam. *Toxopneustidæ*

Gill-cuts at edge of peristome rather obsolete ; globiferous pedicellariæ with or without side teeth on the valves, never with dumbbell-shaped spicules 3

3. Globiferous pedicellariæ with teeth on both sides of the valves, below the end tooth ; head directly attached to the end of the stalk, without a neck. Spicules simply C-shaped

I. Fam. *Echinidæ*

Globiferous pedicellariæ without side teeth on the valves ; head attached to the end of the stalk by means of a distinct neck.

Spicules with branched ends . III. Fam. *Strongylocentrotidæ*

[Fam. TEMNOPLEURIDÆ]

Test with grooves or pits in the horizontal sutures, or with the plates ornamented by depressions or indentations in the tubercle bases, rarely (in some small deep-sea forms) without any such special marks. Tubercles crenulate or smooth. Gill-cuts small. Globiferous pedicellariæ of very different character.

This family is divided into two subfamilies, one the *Temno-pleurinae*, characterised through having deep pits at the ends of the horizontal sutures and the plates united by small knobs and sockets, the other, the *Temnechininae* (or *Trigonocidarinae*), with no sutural pits, at most some low sutural depressions, but usually with the plates ornamented by grooves or indentations in the tubercle bases, the plates not united by knobs and sockets. While the first of these subfamilies is confined to the Indo-Pacific, the *Temnechininae* have representatives also in the Atlantic, namely the following three genera : *Trigonocidaris* A. Agass., with the species *Tr. albida* A. Agass., known from the Bay of Biscay ("Caudan") and off the Azores and Madeira ("Princesse Alice"), further from the West Indies and the Indo-Pacific ; bathymetrical distribution ca. 200-900 m. ; *Genocidaris* A. Agass., with the species *G. maculata* A. Agass. (Syn. *Temnechinus maculatus* (A. Agass.), *Arbacina Pallaryi* Gauthier), known from the Mediterranean, the African coast down to Congo, the Azores, the West Indies, and the east coast of N. America ; bathymetrical distribution, ca. 20-420 m. ; *Hypsiechinus* Mrtsn., with the species *H. coronatus* Mrtsn., known only from S.W. of Iceland and the Denmark strait, 810-1440 m. It is quite probable that all these three forms will be found to occur also off the British coasts. They are thus distinguished :

1. A single large, round plate covers the whole periproct. Base of the primary tubercles more or less deeply indented. Globiferous pedicellariæ with a single tooth, on one side only,

beneath the end tooth. Peristome naked, excepting the buccal plates. Test usually reddish and white spotted

Genocidaris maculata A. Ag.

Some smaller plates on the periproct besides the large anal plate; peristome outside the buccal plates covered by large plates. Test and spines white 2

2. Test ornamented with numerous rather large, irregular grooves. Globiferous pedicellariæ with a single, unpaired tooth beneath the end tooth. Spicules C-shaped

Trigonocidaris albida A. Agass.

Test smooth, at most a fine reticulation in the larger specimens.

Globiferous pedicellariæ with 2-4 lateral teeth on either side, beneath the end tooth. Spicules irregular 3-radiate. The female with the apical area raised into a prominent knob

Hypsiechinus coronatus Mrtsn.

All three forms are very small, scarcely exceeding 10-15 mm. in horizontal diameter. *Hypsiechinus* protects its brood, the young ones being found attached round the apical knob, covered by the spines. The development of the two other species is unknown, but *Genocidaris maculata* may be expected to have a typical pelagic larva.

I. Family ECHINIDÆ

Test without depressions or pits; tubercles smooth. Ambulacral plates with three or more pore pairs (oligoporous or polyporous). Gill-cuts not deep, more or less obsolete. Globiferous pedicellariæ with one or more teeth on both sides of the valves, beneath the end tooth, and with head attached directly to the end of the stalk, without a neck; no mucous glands on the stalk. Spicules simply C-shaped (Fig. 144, 4).

Three genera represented in the British (and European) seas.

Key to the genera of Echinidæ represented in the British seas.

1. Ambulacral plates with 3 pairs of pores ("oligoporous") 2
- " " " 5-6 " " ("polyporous")

3. *Paracentrotus* Mrtsn.

2. Buccal membrane usually closely packed with thick plates; globiferous pedicellariæ with outer part of valves (the blade) quite open, without cross beams, and with several teeth along each side (Fig. 144, 1) 1. *Psammechinus* L. Agass.

Buccal membrane with few, thin plates; globiferous pedicellariæ with blade more or less tube-shaped, the edges connected by cross beams; one or a few teeth along each side of the blade (Fig. 144, 2) 2. *Echinus* Linn.

1. *Psammechinus* L. Agassiz.

Test closely set with spines (tubercles) of nearly equal size, the primary series not very conspicuous. Three pore pairs in each ambulacral plate. Globiferous pedicellariæ with outer part of valves (the "blade") rather broad, open, the edges thin and not connected by cross beams on the inside; a series of teeth along each side of blade (Fig. 143, 2-3; 144, 1). Buccal membrane usually closely packed, as if imbricated, with thick plates. Small or moderate sized forms of greenish colour.

One species known from the British seas. Another species, *Ps. microtuberculatus* (Blainville), is very common in the Mediterranean, but occurs also on the Atlantic coasts to Cape Verde in the south and the Portugal coast in the north. There is, perhaps, a possibility that this species may occur as far north as the British south coasts.

Key to the species of Psammechinus known from or possibly occurring in the British seas.

Spines rather coarse, usually with violet point; plates of buccal membrane consisting of usual calcareous network, not greenish. A rather robust form, up to 50 mm. horizontal diameter

1. *Psammech. miliaris* (Gmelin)

Spines fine and slender, with reddish point; plates of buccal membrane of compact, greenish calcareous substance, with only some tube-shaped holes in them. A rather delicate form, usually not exceeding 35 mm. horizontal diameter

Psammech. microtuberculatus (Blainv.)

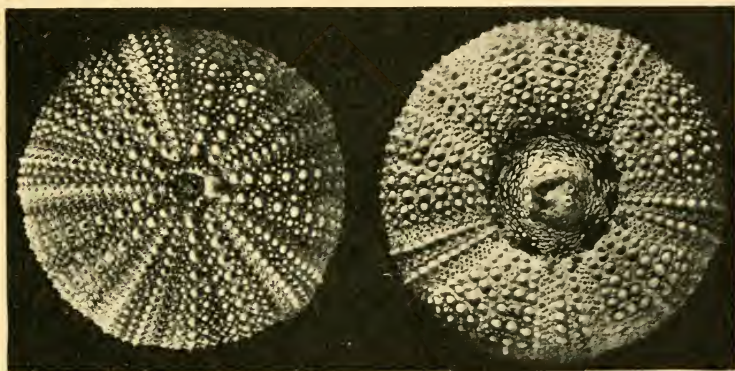
1. *Psammechinus miliaris* (Gmelin). (Fig. 166.)

(Syn. *Echinus miliaris*; *Parechinus miliaris* (Müll.).)

Test rather depressed, often subpentagonal in circumference, closely set with rather robust, short spines, the primary ones being not very conspicuous; on the naked test the series of primary tubercles are, however, fairly distinct. There is a primary tubercle on every ambulacral plate. Apical system rather small, none of the ocular plates in contact with the periproct. The buccal plates with numerous pedicellariæ, but with no spines. The plates of the buccal membrane of usual reticulate structure, not greenish. Globiferous pedicellariæ (Fig. 143, 2-3; 144, 1) small, usually very numerous, looking with their white heads, on well preserved specimens, like a down

among the spines. Tridentate pedicellariæ rather coarse, with broad, leaf-shaped valves. Colour greenish, both the test and spines, but the point of the spines usually violet. Grows to a size of up to ca. 50 mm. in horizontal diameter.

The breeding season is essentially in the early summer months, but specimens with ripe genital products may be met with all the time from February to November. The *larva* has in the I. stage elongate body-rods, with the point somewhat thickened and branched (Fig. 147, 1-2; 148, 1); in the II. stage it has epaulettes at the base of the postoral and postero-dorsal arms, but none at the posterior end of the body. This species can form hybrids with *Echinus esculentus*.



1

2

FIG. 166.—*Psammechinus miliaris*; naked test from above (1) and below (2).
Nat. size.

It appears to be rather omnivorous; according to the bottom on which it lives, its food consists of *Zostera*, algæ, or all sorts of bottom organisms. It is accused of doing damage on the oyster banks off the Thames.

This species is common all round the British coasts; also known from the Rockall Bank. It is essentially a littoral form, living among sea-grass, algæ, often found under stones and on rocks within the tide limits. It has been recorded as boring holes in the rocks, like *Paracentrotus lividus*. It is distributed from the Trondhjem Fjord along the Scandinavian coasts to the Baltic and the North Sea, and from Iceland to Morocco and the Azores, but is not found in the Mediterranean. It does not occur at Greenland or the Atlantic coasts of America. Bathymetrical distribution, 0-ca. 100 m.

2. *Echinus* Linnaeus.

Test more or less closely set with spines (tubercles), among which the primaries are often very conspicuous. Three pore pairs in each ambulacral plate. Buccal membrane with few, usually thin, plates, mostly imbedded in the skin, which appears rather naked. Globiferous pedicellariæ with the edges of the blade thickened and usually united by cross-beams over the inside, forming thus

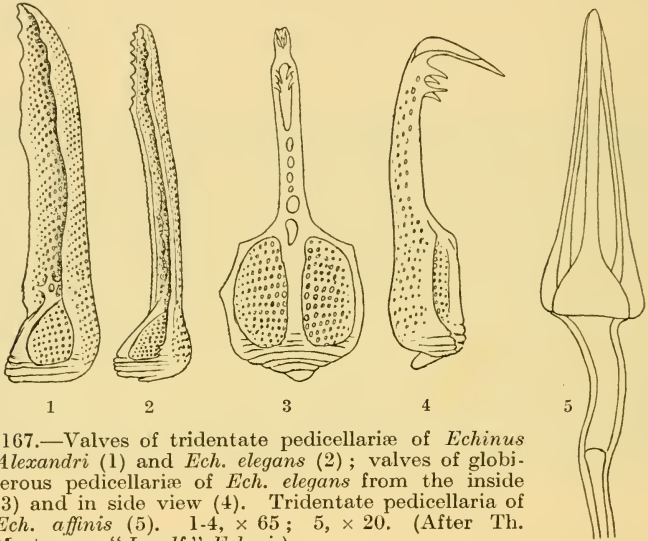


FIG. 167.—Valves of tridentate pedicellariæ of *Echinus Alexandri* (1) and *Ech. elegans* (2); valves of globiferous pedicellariæ of *Ech. elegans* from the inside (3) and in side view (4). Tridentate pedicellaria of *Ech. affinis* (5). 1-4, $\times 65$; 5, $\times 20$. (After Th. Mortensen, “Ingolf” *Ech.*, i.)

a more or less closed tube; few (1-3) lateral teeth on each side (Fig. 167, 3-4). Chiefly large forms, often of beautiful colour.

Seven species are known from the British and European seas. They are thus distinguished:

*Key to the species of Echinus known from the British
(and European) seas.*

- | | | |
|--|---|---|
| 1. A primary tubercle only on every second ambulacral plate, or even several plates in succession without a primary tubercle | 1 | 2 |
| A primary tubercle on all the ambulacral plates | . | 5 |
| 2. All the interambulacral plates with a primary tubercle | . | 3 |

¹ In very young specimens of this section there is a primary tubercle on each ambulacral plate. Such young specimens cannot be identified alone by the key, and often, indeed, they cannot be identified with certainty.

- Only every second (or less) of the interambulacral plates on the upper side with a primary tubercle. Primary spines rather small, greenish. Test globular, of a brownish tint; grows to a very large size 4. *Ech. melo* Lamk.
3. Test white, globular; tubercles (spines) rather scarce; small spines on the buccal plates 2. *Ech. tenuispinus* Norman
Test more or less conspicuously coloured with red or greenish 4
4. Test more or less globular, mostly uniformly red, tubercles white; secondary tubercles (spines) numerous, of about the same size as the primaries; small spines on the buccal plates
1. *Ech. esculentus* Linn.
Test more or less conical, often flattened; the red colour not covering the whole test, but interrupted by white, vertical bands, or the red is confined to a small patch in the interambulacra near the apical system. Secondary tubercles (spines) usually distinctly smaller than the primaries. No spines on the buccal plates 3. *Ech. acutus* Lamk.
5. Primary ambulacral tubercles form regular, equal-sized series 6
Primary ambulacral tubercles either of very unequal size, or, if decreasing regularly in size towards the apical system and the peristome, the two series in each ambulacrum of very unequal size. Test white. Tridentate pedicellariæ very slender (Fig. 167, 5) 7. *Ech. affinis* Mrtsn.
6. Test usually low, conical or arched; generally with a more or less distinct trace of red or violet colour; spines often beautifully red with white tips. Globiferous pedicellariæ usually with 2-3 lateral teeth; tridentate pedicellariæ with rather narrow valves (Fig. 167, 2) 5. *Ech. elegans* Düb. and Kor.
Test usually flattened above; colour white or (the skin and spines) a faint reddish-yellow. Globiferous pedicellariæ usually with 3-4 lateral teeth; tridentate pedicellariæ with broad leaf-shaped valves (Fig. 167, 1)
6. *Ech. Alexandri* Dan. and Kor.

1. *Echinus esculentus* Linnæus. (Fig. 168.)

(Syn. *Echinus sphaera* O. Fr. Müller.)

Test usually globular, more rarely somewhat depressed or subconical. It is rather closely covered with short spines, among which the primaries are scarcely conspicuous; in correspondence with this the primary and secondary tubercles are of about the same size, and the longitudinal series of the primary tubercles very indistinct. This, however, holds good only for the larger specimens; in the smaller specimens the secondary spines and tubercles are not so large as the primaries, and the longitudinal series of the latter, therefore, are fairly conspicuous. Only every second or third ambulacral plate carries a primary tubercle.

The buccal plates carry some small club-shaped spines among the numerous, mostly ophicephalous pedicellariæ. Globiferous pedicellariæ fairly large, usually with only one lateral tooth on each side, below the end tooth. Tridentate pedicellariæ with long, slender valves. Colour of test an intense red, on which the white tubercles are very conspicuous; more rarely it is pale purplish or pale green. Spines reddish, usually with violet point. Grows to a very considerable size, the largest recorded being 176 mm. horizontal diameter, and is thus one of the largest Echinoids.

The variety *fuscus* Mrtsn. (Syn. var. *depressus* Süssbach and Breckner) differs from the typical form by being rather

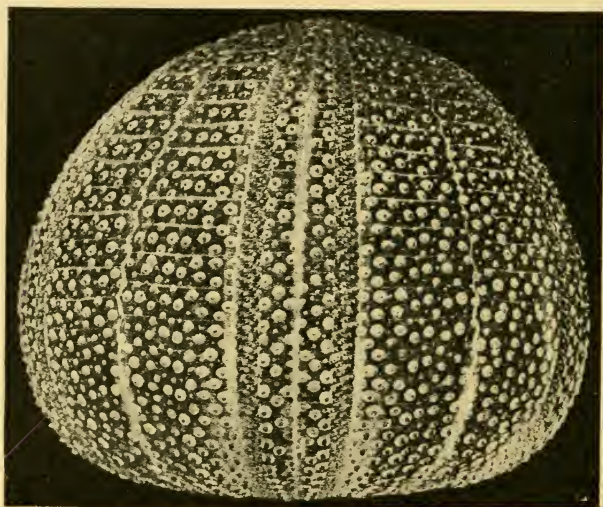


FIG. 168.—*Echinus esculentus*; naked test, in side view. Slightly reduced. (After Koehler; from *Danmark's Fauna*.)

depressed and by its spines being uniformly reddish-brown and somewhat longer than in the typical form. It is fairly common in the North Sea.

Hybrids between *Ech. esculentus* and *acutus* are not rare, where the two species occur together. Also with *Psammechinus miliaris* it may form hybrids. Anomalies in the test are not very rare.

The breeding season is in the early summer months. The larva¹ has in the first stage elongate body-rods with the

¹ *Echinopluteus Théclii* Mrtsn. (*Echinodermenlarven d. Plankton Exped.*, p. 97) is the larva of *Echinus esculentus*; there is no reason for maintaining this name.

point slightly thorny, not thickened, bent somewhat inwards (Fig. 148, 3); in the second stage it has epaulettes both at the base of the postoral and postero-dorsal arms and at the posterior end of the body (Fig. 147, 3). The young sea-urchin reaches in the course of its first year a size of ca. 4 cm. in horizontal diameter, and is then already sexually mature; when 2 years old it is 4.7 cm., 3 years old 7.9 cm., 4 years old 9.11 cm.¹ The very large specimens of 15-16 cm. diameter are therefore probably 7-8 years old. The food consists of both algæ (*e.g.* *Laminaria*, especially when covered with Bryozoa) and all sorts of minor animals, especially barnacles. As food for man this species is much used in Portugal; according to Pennant it was also formerly thus used by the poor in many parts of England. As parasites are found in this species the Nematodes *Oncholaimus echini* Leydig and *Ichthyonema Grayi* Gemmill and Linstow, and the Planarian *Syndesmis echinorum* Shipley. Among its spines is not rarely found a polychæte worm, *Flabelligera affinis* M. Sars.

In British seas this species is common all round the coasts, from the littoral zone (where it is, especially in the breeding season, found among the algæ on the rocks) down to ca. 40 m., becoming much rarer beyond that depth and only exceptionally found in greater depths than ca. 100 m. It is recorded from the Lousy Bank. It is elsewhere distributed from Finmark and Iceland to the coasts of Portugal, but is not known from the Mediterranean. Various statements of its occurrence outside the European seas are erroneous, resting on unreliable labelling. Bathymetrical distribution, 0-ca. 1200 m.

2. *Echinus tenuispinus* Norman. (Fig. 169.)

(Syn. *Echinus esculentus*, Var. *tenuispinus* Norman.)

Test globular, on the upper side rather bare, the secondary tubercles being few and scarce, smaller than the primary tubercles, which form fairly distinct longitudinal series. Spines short and slender. On the oral side the spines and tubercles are more numerous and larger. Only every second ambulacral plate has a primary tubercle, the other plates, especially at the ambitus, usually having a larger secondary tubercle in the median part and another a little outside the primary series, near the pores; on those nearer the apical system the inner tubercle is more often wanting. Small spines on the buccal plates. Pedicellariæ as in

¹ According to observations by Elmhirst.

Ech. esculentus. Colour of test white, or with a slight greenish tint; spines white. Largest size recorded is 57 mm. horizontal diameter.

Biology and development unknown.



FIG. 169.—*Echinus tenuispinus*, side view. Nat. size.

This species, which is known only from the British seas, was first found by Canon Norman 25-30 miles north of Unst, in ca. 200 m. (hard bottom); more recently some specimens were taken by the "Helga" on the "Porcupine" Bank and a few other places off the Irish west coast, in ca. 130-200 m.

3. *Echinus acutus* Lamarek. (Fig. 170.)

(Syn. *Echinus Flemingii* Forbes; *Ech. depressus* G. O. Sars; *Ech. rarispinus* G. O. Sars.; *Ech. cantaber* Lambert and Thiéry.)

Test more or less high, usually subconical, not globular as in *Ech. esculentus*. Spines rather scarce on the upper side, the primaries conspicuously longer and more robust than the secondaries. Primary tubercles forming conspicuous longitudinal series. Only every second or third ambulacral plate carries a primary tubercle. Buccal plates carry only pedicellariæ, no spines. Globiferous pedicellariæ usually with only one lateral tooth on each side; the tridentate pedicellariæ with long, slender valves, up to 2.5 mm. long (Figs. 143, 5; 144, 2). Colour usually whitish, with a red-brown stripe along each series of plates; these stripes may be of varying breadth and the general colour in accordance herewith becomes now more whitish, now more reddish-brown. Along the edges of the plates are often seen alternating, parallel

red-brown and white lines, which probably represent growth-lines. Spines usually reddish at the base, white in the point; but they may be more greenish. Grows to about the same size as *Ech. esculentus*, at least to 150 mm. horizontal diameter.

It is a very variable form and has given rise to the establishment of several "species", some of which may be kept as more or less distinct varieties. The typical form, as described above, has been named *Echinus Flemingii* Forbes. A fairly characteristic small form, depressed, with long and slender spines and with five conspicuous red-brown spots around the apical system, is the Var. *norvegicus* Düben and Koren, and another likewise very depressed form, characterised by its

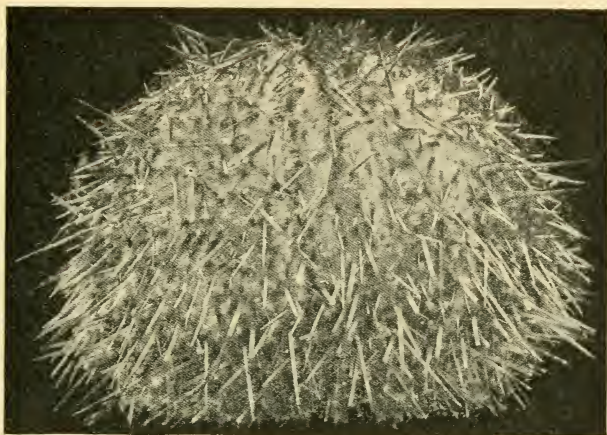


FIG. 170.—*Echinus acutus*, in side view. About nat. size.
(After Koehler; from *Danmark's Fauna*.)

exceptionally small peristome, is the Var. *microstoma* Wyv. Thomson.

Hybrids between this species and *Ech. esculentus* are not rare in places where these two species live together. The parasitic Planarian *Syndesmis echinorum* also occurs in this species.

The breeding season is in the summer months. The larva very much resembles that of *Ech. esculentus*. In the I. stage it is easily recognisable by its rather strongly spiny body-rods, which are slightly thickened and only slightly inwards bent (Fig. 148, 2); the II. stage is hardly to be distinguished with certainty from that of *Ech. esculentus*; generally the arms are a little more slender and more diverging than in the latter.

The food consists of various kinds of bottom organisms, but also simple bottom material may fill the intestine.

In British seas this species is common off the south-west and north coasts, especially in depths of ca. 200-1000 m.; on the North Sea coasts it is not known farther south than St. Andrews, and in the open North Sea it does not appear to occur south of the 100 m. line. The Var. *microstoma* is known only from off the west coasts, e.g. from the Lousy Bank. It is elsewhere distributed from Bear Island in the north to Cape Bojador and the Mediterranean in the south; it is not known from outside the N.E. Atlantic area, statements to this effect being erroneous. The bathymetrical distribution is ca. 20-1280 m.

4. *Echinus melo* Lamarck. (Fig. 171.)

Test globular, not subconical. Primary tubercles very scarce, not only in the ambulacra but also in the interambulacra, on the

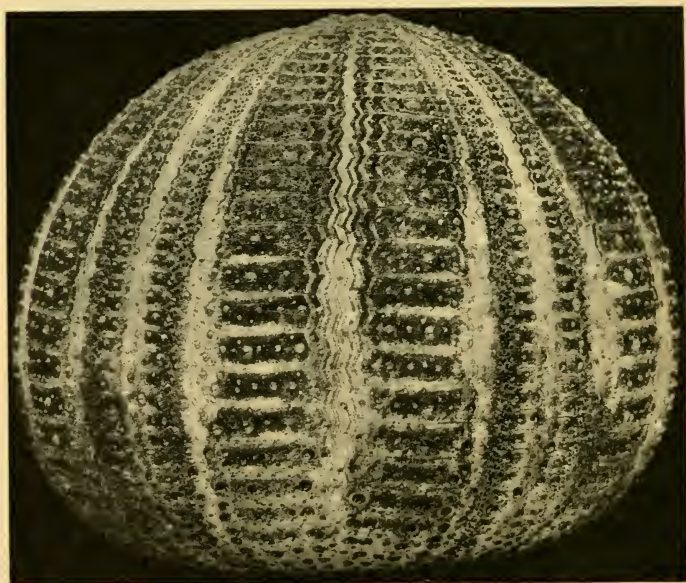


FIG. 171.—*Echinus melo*; naked test, in side view. Somewhat reduced.
(After Koehler, *Echinod.*, *Faune de France*.)

upper side lacking on every second or third plate. Secondary tubercles small and scarce, the series of primary tubercles therefore distinct, although incomplete. Primary spines rather short and slender. No spines on the buccal plates. Pedicellariæ as in

Ech. acutus. Colour of test brownish, usually with conspicuous alternating lines of white and brownish along the edge of the plates. Primary spines greenish. Grows to a considerable size like the preceding species, perhaps still larger.

Development unknown. Appears to prefer a rocky bottom.

In British seas this species appears to be rather rare, but as it has formerly generally been confounded with *Ech. acutus* it is quite possible that it is not quite so rare as would appear from literature. It has been recorded from off North Rona ("Knight Errant", Agassiz) and from Cornwall (Forbes); there is, however, no certainty that these were true *Ech. melo*. But Farran records a specimen from 53° 1' N., 14° 34' W., 525 m. ("Helga"), which is seen from the description to be a true *Ech. melo*.

The species is elsewhere known from the Mediterranean, the coasts of Portugal, and the Azores. Bathymetrical distribution ca. 30-1100 m.

5. *Echinus elegans* Düben and Koren. (Fig. 139.)

Test low, usually arched. Primary spines rather large, forming—like the tubercles on the test—very distinct, regular longitudinal series; secondary spines and tubercles distinctly smaller than the primaries. Each ambulacral plate carries a primary spine (tubercle), the two series in each ambulacral area being of equal size. No spines on the buccal plates. Globiferous pedicellariæ usually with 2-3 lateral teeth on each side of the blade. Tridentate pedicellariæ with fairly broad valves, of a size up to 2 mm. length of head (Fig. 167, 2). Colour of the test usually whitish, with a reddish tint on the upper side; sometimes violet. Spines exquisitely pink with white tip (not fading in alcohol), or uniformly reddish or yellowish. Reaches a size of ca. 80 mm. horizontal diameter.

Biology and development unknown.

In British seas this species has been found at various places off the west coast of Ireland¹ and Scotland to north of the Shetlands; it is also recorded from the east coast of Scotland. Apparently it is nowhere common. It is elsewhere known from the Trondhjem Fjord and S. of Iceland to the Bay of Biscay and the Azores; its occurrence in the Mediterranean, as also on the

¹ Partly recorded under the erroneous name *Echinus gracilis* (Düb. and Kor.).

N. American east coast (*Echinus Wallisi* A. Agass.), is uncertain. Bathymetrical distribution ca. 50-2000 m.

6. *Echinus Alexandri* Danielssen and Koren. (Figs. 172, 173.)

Test flattened on the upper side. Primary tubercles forming very distinct regular series, the secondaries, which are not very numerous, being much smaller than the primaries. The primary spines sometimes very long and rather stout, raised upwards. Every ambulacral plate with a primary tubercle, the two series being very regular, equal sized. No spines on the buccal plates.

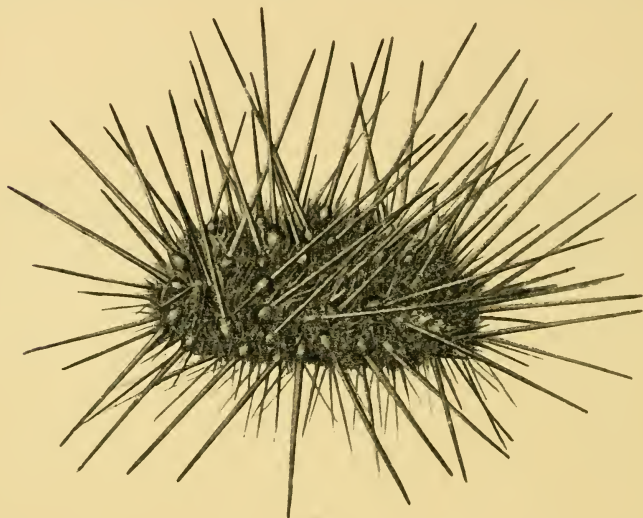


FIG. 172.—*Echinus Alexandri*; side view. Somewhat reduced.
(After Koehler, *Echinodermes du "Caudan"*.)

Globiferous pedicellariæ usually with 3-4 lateral teeth on each side of blade. Tridentate pedicellariæ with very broad, leaf-shaped valves (Fig. 167, 1); they may be rather large, up to 2.5 mm. length of head. Colour in life light pink (fading in alcohol); the naked test white. Reaches a size of ca. 70 mm. in horizontal diameter.

Biology and development unknown.

In British seas this species has been found off S.W. Ireland, (50° 25' N., 11° 44' W., 1797 m., "Michael Sars"). No doubt it will prove to have a wider distribution off the west coast of Ireland. It is elsewhere known from S. of Iceland to the Bay of

Biscay and the Azores. The bathymetrical distribution is 790-3120 m.

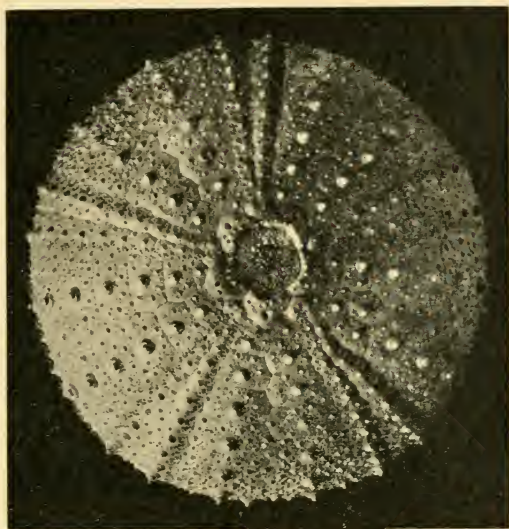


FIG. 173.—*Echinus Alexandri*; naked test, from above. Nat. size.

7. *Echinus affinis* Mrtsn. (Fig. 174.)

Test low, but rounded or subconical, not flattened above. The primary tubercles of the interambulacra form regular, prominent series, while those of the ambulacra are remarkably unequal, either so that the two series in each ambulacrum are regular, but of unequal size, or so that suddenly some of the tubercles, especially at the ambitus, become much larger than the others. Secondary tubercles on upper side few and small. Primary spines fairly long and slender. No spines on the buccal plates. Globiferous pedicellariæ generally with 2 lateral teeth on each side of the blade. The tridentate pedicellariæ (Fig. 167, 5) with very slender valves. They reach a size of up to 2.2 mm.

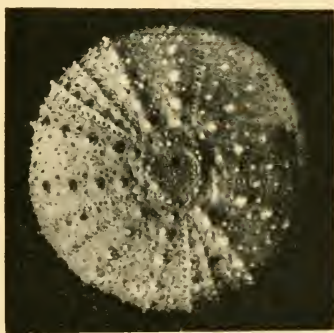


FIG. 174.—*Echinus affinis*; naked test, from above. Nat. size.

length of head. Colour (in a preserved state) white. Not known to exceed ca. 40 mm. horizontal diameter.

This species has a considerable resemblance to *Echinus acutus*, Var. *norvegicus*, but is easily distinguished from it by its entirely white colour. Also the arrangement of the primary ambulacral tubercles is different, there being here, in spite of the irregularity in the size of the tubercles, a primary tubercle on each ambulacral plate (as seen from the fact that they are placed in a regular series), not only on every second or third plate as in *norvegicus*.

Biology and development unknown. Two species of parasitic molluscs have been found infesting this species, viz. *Pelseneeria profunda* Koehler and Vaney, and *P. media* Koehler and Vaney.

From British seas this species has only been recorded with certainty from off the Rockall Bank, 1750 m. ("Valdivia"). No doubt it will be found to occur off the west coast of Ireland and Scotland. It is known elsewhere from S. of Iceland to the Azores, and also from off the east coast of N. America. The bathymetrical distribution is ca. 770-2180 m.

3. *Paracentrotus* Mrtsn.

Test rather closely covered with spines (tubercles), among which the primaries are fairly conspicuous. Ambulacral plates with 5-6 pore pairs each (polyporous). Buccal membrane with only small plates outside the buccal plates, thus rather naked. Globiferous pedicellariæ with only 1 lateral tooth to each side, beneath the end tooth; the blade not tube-shaped, without transverse beams across the inside (Fig. 176, 1).

Only one species in British (and European) seas.

1. *Paracentrotus lividus* (Lamarck). (Fig. 175.)

(Syn. *Toxopneustes lividus* (Lmk.); *Strongylocentrotus lividus* (Lmk.).)

Test rather low, but rounded. The primary tubercles form very regular, fairly conspicuous longitudinal series, the secondary tubercles smaller, not very numerous. Every ambulacral plate carries a primary tubercle. Primary spines fairly long and robust. Globiferous pedicellariæ (Fig. 176, 1) without glands on the stalk. Tridentate pedicellariæ with narrow, slender valves, with the edge distinctly serrate (Fig. 176, 2). Colour dark violet to brownish or olive-greenish; the test greenish. Does not grow

to any large size, the horizontal diameter scarcely exceeding 70 mm.



FIG. 175.—*Paracentrotus lividus* ; partly denuded. Slightly reduced.
(After Agassiz, *Revision of Echini.*)

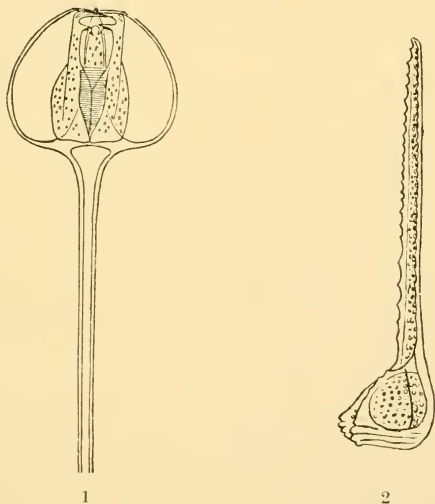


FIG. 176.—Globiferous pedicellaria and valve of tridentate pedicellaria of *Paracentrotus lividus*. 1, $\times 33$; 2, $\times 40$. (After Th. Mortensen, *Echin. d. Mittelmeeres* and “Ingolf” *Ech.*, i.)

The breeding season is in the summer months (in the Mediterranean nearly throughout the year). The *larva* (Fig. 177) has in the I. stage elongate, club-shaped, rather thorny

body-rods. In the II. stage it has epaulettes at the base of the postoral and postero-dorsal arms; but how to distinguish it from the II. stage of the *Psammechinus miliaris* larva, which has likewise epaulettes only at the base of the four main arms, we cannot see in the present stage of our knowledge.

It is a littoral form, often found on rocky shores; it bores holes in the rocks, and great numbers usually are found together, each in its hole, the rocks being quite honeycombed by them.¹ Also among *Zostera* they may occur in great numbers. They often cover themselves with fragments of *Zostera* leaves

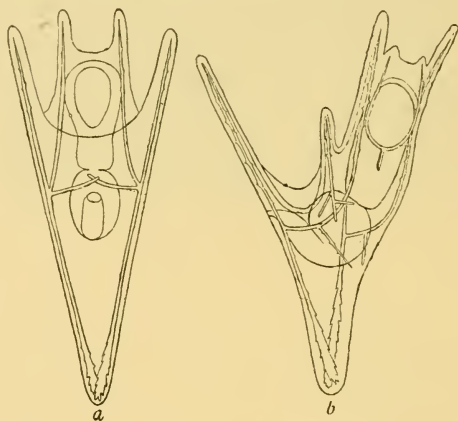


FIG. 177.—Larva of *Paracentrotus lividus*. (After Joh. Müller, IV. Abhandl. über Echinod. larven.)

a, From the ventral side; *b*, half from the dorsal side.

and the like, thus hiding themselves. In the Mediterranean countries this species is highly esteemed as food, and an important fishery is based on it (and also on *Sphærechinus granularis*). Various Infusorians are found parasitic in this Echinoid: *Anophrys echini* di Mauro and *Cryptochilum echini* Maupas in the intestine, *Colpidium echini* Russo in the rectum; also the Planarian *Syndesmis echinorum* occurs in this species.

In British seas this species is common on the south and west coasts of Ireland, and has also been found on the Devon and Cornwall coasts (Ilfracombe, Falmouth). It is elsewhere distributed along the European coasts from the Channel to the

¹ In the *Clare Island Survey*, Part 67, Pl. III. (R. Southern, "Marine Ecology", *Proc. R. Irish Acad.*, xxxi., 1915), is given a very fine representation of a colony of these rock-boring sea-urehins.

Mediterranean, the Moroccan coast, the Canaries, and Azores. The bathymetrical distribution is 0-30 m.

II. Family TOXOPNEUSTIDÆ

Test without depressions or pits; tubercles smooth. Ambulacral plates with three or more pore pairs (oligoporous or poly-porous). Gill-cuts sharp and deep. Globiferous pedicellariæ without lateral teeth, the outer part of the valves (the blade) a closed tube; the head attached directly, without a neck, to the end of the stalk. Usually mucous glands are found on the stalk (Fig. 179, 1). Dumbbell-shaped spicules, or at least spicules with the ends thickened, in the skin of the globiferous pedicellariæ (Fig. 179, 3). Spicules of the tube-feet C-shaped or branched.

The head of the globiferous pedicellariæ is not rarely lost, the stalk with its mucous glands remaining; or the head may be more or less rudimentary or even be not at all developed. Such rudimentary or mutilated globiferous pedicellariæ have been regarded as a special sort of organs, the "Globifera" or the "Cystacanth"; but there is no doubt that they are globiferous pedicellariæ in which the head has been reduced or torn off.

Only one genus of this family occurs in the British (and European) seas, whereas the family is very richly developed in the Indo-Pacific.

1. *Sphærechinus* Desor.

Test rather closely covered with spines (tubercles) of a uniform size, the primaries being hardly distinguishable. Each ambulacral plate with 4 pore pairs. Buccal membrane with few small but rather thick plates outside the buccal plates. Spicules of globiferous pedicellariæ C-shaped, with the end thickened, not typically dumbbell-shaped; those of the tube-feet C-shaped, with the ends branched.

Only one species in British (and European) seas, the only species known of this genus.

1. *Sphærechinus granularis* (Lamarck). (Fig. 178.)

(Syn. *Echinus* (*Toxopneustes*) *brevispinosus* Risso; *Ech. æquituberculatus* Desmoulins; *Sphærechinus roseus* Russo.)

Test low, but arched, not flattened; spines short, rather thick; the larger tubercles arranged in a fairly distinct transverse series on each plate, especially at the ambitus. Primary tubercles on all the ambulacral plates. No spines on the buccal plates. Globiferous pedicellariæ with rather short valves.

Tridentate pedicellariæ with rather broad, leaf-shaped valves (Fig. 179, 2). Colour of the spines usually violet, with the point white; test purplish-violet. Grows to a considerable size, ca. 130 mm. horizontal diameter.

Breeding season in the summer-time or (in the Mediterranean), throughout most of the year. The larva in the I. stage has a short, rounded body, the body-rods not prolonged, but united by a transverse rod with the recurrent rods, so as to form

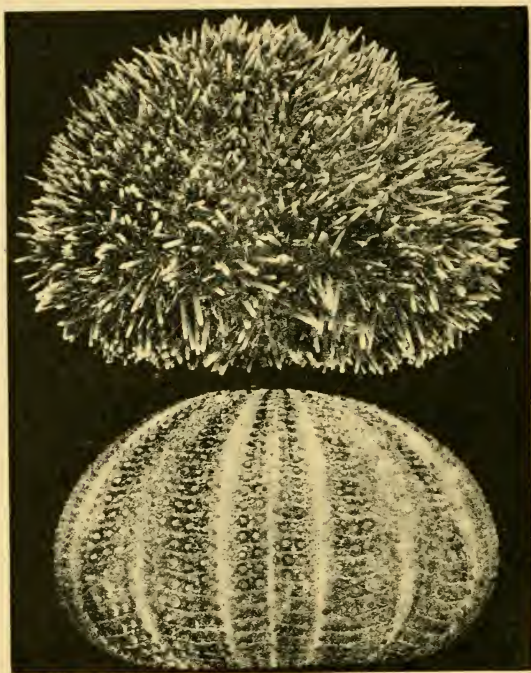


FIG. 178.—*Sphaerechinus granularis*; specimen with the spines preserved, and a naked test; side view. Slightly reduced. (After Koehler, *Echinod.*, *Faune de France*.)

a basket structure. This young larva is very much like the young larva of *Echinocyamus pusillus*, and is hardly distinguishable with certainty from the latter (cf. Fig. 183, 1); as soon as the postero-dorsal rods have appeared, they are easily distinguishable, the *Echinocyamus* larva having both postoral and postero-dorsal rods fenestrated, while in the *Sphaerechinus* larva only the postoral rod is fenestrated. In the II. stage the larva has a posterior transverse rod, simply bifurcating at the ends, the lower branch not developed into a long postero-lateral rod such as is

the case in the *Arbacia* larva (Fig. 165). A broad epaulette is found at the base of each postoral and postero-dorsal arm

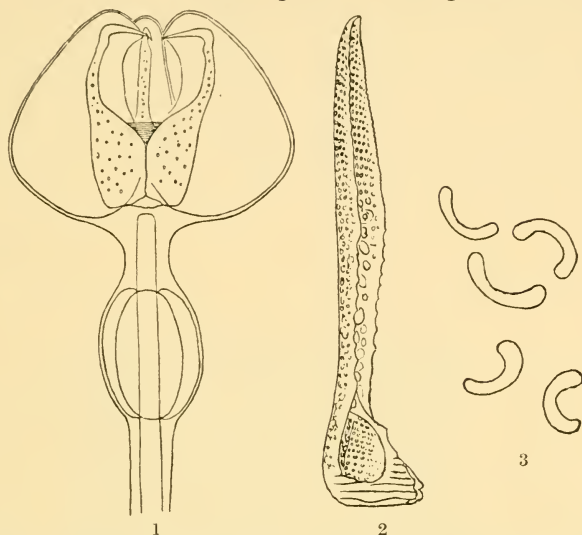


FIG. 179.—Globiferous pedicellaria (1), valve of tridentate pedicellaria (2), and spicules from globiferous pedicellariæ (3) of *Sphærechinus granularis*. 1, $\times 27$; 2, $\times 40$; 3, $\times 500$. (After Th. Mortensen, *Ech. d. Mittelmeeres* (1) and "*Ingolf*" *Ech.*, i. (2-3).

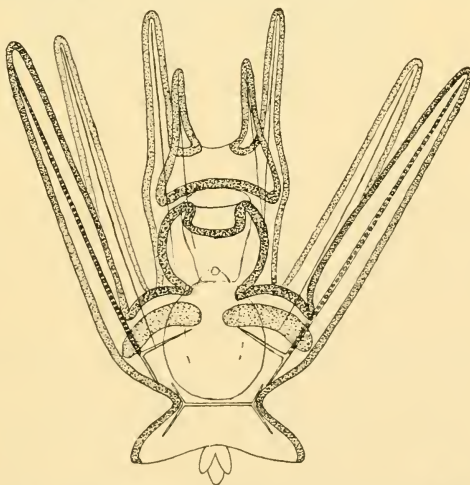


FIG. 180.—Larva of *Sphærechinus granularis*. (After Joh. Müller, VII. Abh über Echinod.-larven; slightly corrected.)

(Fig. 180). Rate of growth of the sea-urchin unknown, but it may be already sexually mature at a size of 8 mm. horizontal

diameter. It is a littoral form, found especially among the *Zostera*.

In the British seas proper this species has not been found ; but as it occurs at the Channel Islands it may be justifiable to include this important type among the British echinoderms (as is also done by Bell and Hoyle). It is distributed from the Channel Islands to Cape Verde and the Azores and the Mediterranean ; especially in the Mediterranean it is very common. Bathymetrical distribution, 0-ca. 50 m.

III. Family STRONGYLOCENTROTIDÆ

Test without depressions or pits ; tubercles smooth. Ambulacral plates with more than three pore pairs (polyporous). Gill-cuts small and obsolete. Globiferous pedicellariæ without lateral teeth, the outer part of the valves (the blade) a closed tube ; the head articulated to the stalk by means of an extensile and retractile neck (Fig. 143, 6 ; 144, 3) ; no mucous glands on the stalk. Spicules of globiferous pedicellariæ and tube-feet C-shaped, with the ends branched (Fig. 144, 5).

Only one genus represented in the British (and European) seas, the only genus known of this family.¹

1. *Strongylocentrotus* Brandt.

Characters the same as those of the family. Each ambulacral plate carries a primary tubercle.

Only one species in the British (and European) seas, and, on the whole, in the Atlantic, whereas several species are found in the Northern Pacific ; here, evidently, is the home of the genus, from which one species has spread into the Atlantic.

¹ H. L. Clark includes within the family Strongylocentrotidæ a number of genera, mainly polyporous forms, which, in the opinion of the present author, are not more nearly related with *Strongylocentrotus* but belong to the families Echinidæ, Toxopneustidæ, and Echinometridæ. It is not the place here to enter on a discussion of these questions, but one main thing may be emphasised, viz., that the polyporous condition of the ambulacral plates is no proof of relationship, as it has quite certainly arisen independently within various groups.

1. *Strongylocentrotus dröbachiensis* (O. Fr. Müller). (Fig. 181.)
 (Syn. *Echinus neglectus* Lamk.; *Toxopneustes dröbachiensis* (O. F. Müll.); *Toxopn. pallidus* G. O. Sars; *Toxopn. pictus* Norman; *Strongyloc. granularis* (Say).)

Test low, but arched, not flattened; it is rather closely set with tubercles, among which the primaries form distinct vertical series. In larger specimens also the secondary tubercles form fairly distinct vertical series. Usually 5-6 pore pairs in each ambulacral plate. As a rule two of the ocular plates reach the periproct. Spines of rather uniform length, the primaries not

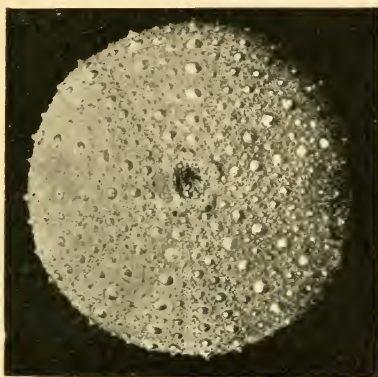


FIG. 181.—Denuded test of *Strongylocentrotus dröbachiensis*, seen from above. Nat. size. (From *Danmark's Fauna*.)

very conspicuous. No spines on the buccal plates. Globiferous pedicellariæ fairly large and conspicuous, usually with numerous spicules arranged in a band along the sides of the valves (Fig. 143, 6). Tridentate pedicellariæ usually with rather broad, leaf-shaped valves. Colour of test mostly greenish-brown, the spines greenish or reddish, sometimes violet, often with whitish point. Reaches a size of ca. 80 mm. horizontal diameter.

The breeding season in the early spring (perhaps also in the winter-time). The larva has in the I. stage elongate, club-shaped body-rods (Fig. 148, 4). In the II. stage it has epaulettes at the base of the postoral and postero-dorsal arms, and a pair at the posterior end of the body, forming almost a closed ring. (Probably the larva designated as *Echinopluteus coronatus* Mrtsn. belongs here.) Otherwise this larva is very

little known, and cannot, for the present, be distinguished in the II. stage from the corresponding larvæ of *Echinus esculentus* and *acutus*.

It is mainly a littoral form, which may bore holes in the rocks. The food consists of all sorts of minor bottom organisms; Hydroïds especially appear to be a favourite food. Also algæ are eaten, and often the intestine is found to be filled with bottom material. A parasitic mollusc, *Pelseneeria stylifera* Turton (Syn. *Styliifer Turtoni* Broderip), is not uncommon on this sea-urchin, and in its intestine the Planarian *Syndesmis echinorum* is found. It is eaten at least by the cod.

In British seas this species occurs along the North Sea coasts, from the Shetland Islands to the southern part of the North Sea, but has not been recorded from the west coasts. It is elsewhere distributed from the Siberian Sea and Spitzbergen to the Sound, from Iceland and Greenland to New Jersey, and in the Northern Pacific to Vancouver and Korea. Bathymetrical distribution, 0-ca. 1200 m.

Very young specimens of the polyporous Echinoids have as yet only 3 pore pairs in the ambulacral plates, and plates with only 3 pore pairs are still found near the peristome in the adult forms. Such young specimens can, however, be determined with certainty by means of their globiferous pedicellariæ, which appear very early. Also the quite young *Psammechinus* and *Echinus* are very easily distinguished by means of their globiferous pedicellariæ. The structure of the pedicellariæ is easily seen under the microscope by applying some glycerine or potash, or on dissolving the tissue by means of a drop of hypochlorite of sodium. On living samples of pedicellariæ the tissue is usually so transparent that the structure of the valves can be seen directly, without any special treatment.

III. Order. CLYPEASTROIDEA

Test elongate or round, usually flattened. Mouth in the middle on the under side, anal opening usually on the under side or at the posterior edge, only exceptionally a small distance above the edge. No gills or gill-cuts at the peristomial edge of the test. Interior of test usually with a complicated system of supporting pillars or walls, connecting the upper and lower floor; this supporting system may be developed to such a degree that the internal organs are wholly enclosed by a calcareous network, or

it may be reduced to inconspicuous partition walls at the edge of the test, or it may be almost totally wanting. Ambulacral plates simple; on the upper side the ambulacra are usually widened ("petaloid"), forming a flower-like figure. Dental apparatus strongly developed. Tubercles perforate. Spines quite small, forming a close, almost velvet-like coat. Tube-feet small, usually many to each ambulacral plate and often spreading also over the interambulacra. Pedicellariæ small and inconspicuous, mostly only tridentate, ophicephalous, and triphyllous. Sphæridia present, but placed in grooves in the test so as not to be externally visible.

This order is richly developed in tropical seas, but has in recent times only a single representative in European seas, whereas numerous fossil (tertiary) forms are known, especially from the deposits of the Mediterranean countries.

I. Family FIBULARIIDÆ

Test usually elongate, flattened or arched. Internal supports of test feebly developed, consisting only of small radiating partition walls at the edge of test, or even almost wholly wanting. Ambulacra only slightly petaloid on upper side. Anal opening on under side of test. Very small forms.

Only one genus in the British (and European) seas.¹

1. *Echinocyamus* (van Phelsum) Leske.

Test usually elongate, flattened; internal radiating partition walls present, bounding the ambulacra. Numerous very small pores (and tube-feet) along the horizontal sutures between the ambulacral plates. Only 1 pore in the madreporite. Four genital pores. Spines of two sorts, somewhat longer, pointed ones, and smaller ones ending in a serrate crown.

Only one species, *Ech. pusillus*, known from the British seas, but two more species may well be expected to occur there likewise, namely *Echinocyamus grandiporus* Mrtsn., known from off the Azores and from the Josephine Bank, also widely distributed in the West Indian seas, ca. 150-1385 m.; *Echinocyamus macrostomus* Mrtsn., known from off the Azores and Cape Verde, 1600-

¹ The record of *Arachnoides placenta* (Linn.) from the Shetland Islands (Forbes) is evidently erroneous; this species, therefore, should no longer be named, even with reservation of doubt, in any record of British echinoderms.

2286 m. ("Princesse Alice", "Valdivia"). The three species are thus distinguished: ¹

Key to the species of Echinocyamus known from or likely to occur in the British seas.

1. Ocular pores distinctly smaller than the genital pores . . . 2
 Ocular pores as large as, or even larger than the genital pores.
 Petals small and inconspicuous . . . *Ech. grandiporus* Mrtsn.
2. Petals small and indistinct; peristome large
 Ech. macrostomus Mrtsn.
 Petals well developed; peristome small
 1. *Ech. pusillus* (O. Fr. Müll.)

1. *Echinocyamus pusillus* (O. Fr. Müller). (Fig. 182.)

(Syn. *Echinocyamus angulosus* (Leske); *Ech. minutus* (Pallas)
 H. L. Clark.)

Test elongate, often somewhat pointed at the anterior end. Petals well developed and distinct, with ca. 6-9 pore pairs in each series. Genital pores distinctly larger than the ocular pores. Colour greyish or greenish. On preservation or when hurt it turns green, a character peculiar to all Clypeastroids. Scarcely exceeding 15 mm. in length.



FIG. 182.—*Echinocyamus pusillus*.
 (From *Danmark's Fauna*.)

1-2. Denuded tests from the upper (1) and under side (2). 3. Specimen covered with its spines, upper side. Nat. size.

This species prefers a bottom of coarse sand or gravel. The food consists of small bottom organisms, especially Foraminifera, remains of plants, and bottom material (detritus) generally. It is rather much eaten by fishes, especially by dab and haddock.

The breeding season is in the summer months. The larva (Fig. 183) is characterised by the body skeleton forming a basket structure. Postoral and postero-dorsal rods fenestrated; no posterior transverse rod or postero-lateral arms; no epaulettes.

In the British seas this species occurs all round the coasts and is probably common everywhere on a coarse sandy or gravelly bottom in shallow depths. It is elsewhere distributed from Finmark to the Sound and the western Baltic, from Iceland to

¹ A full description, with figures, of the two species *grandiporus* and *macrostomus* is given in the "*Ingolf*" *Echinoidea*, ii., pp. 33-37, Pl. XII.

the Azores, Cape Bojador and the Mediterranean, whereas all records of its occurrence in the West Indian seas are due to a

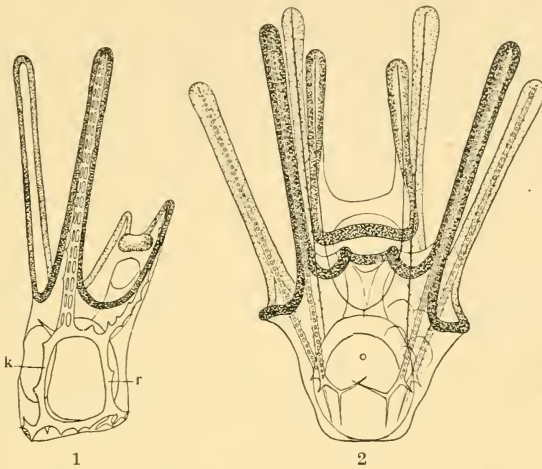


FIG. 183.—Larva of *Echinocyamus pusillus*. (From *Danmark's Fauna*.)

1. I. stage, lateral view; only the skeleton of the upturning side has been drawn (after Théel). 2. II. stage, seen from the oral side. 1, \times ca. 100; 2, \times 35.

confusion with *Ech. grandiporus*. Bathymetrical distribution from lower tide limit to 1250 m.

IV. Order. CASSIDULOIDEA

Test elongate or round, not flattened. Mouth central or anterior, anal opening posterior, often in a depression, or on the under side. No gills or gill-cuts at peristomial edge of test. No internal supporting system of pillars. No dental apparatus. Ambulacra simple or petaloid on upper side and often also widened at the mouth. Posterior interambulacrum not different from the others on the oral side. Tubercles imperforate. Spines small, those on the lowermost interambulacral plate usually somewhat larger, flattened, bending over the mouth, which is thus covered by 5 fan-shaped groups of spines. No fascioles. Tube-feet confined to the ambulacra; oral tube-feet not penicillate. Pedicellariæ small, usually the tridentate, ophi-cephalous, and triphyllous form present. Sphæridia present, placed in more or less closed grooves.

One family represented in British (and European) seas.

I. Family CASSIDULIDÆ

Diagnosis same as that of the order.¹

Only one genus, *Neolampas*, known to occur in the British (and European) seas. Two more genera, *Echinolampas* Gray and *Conolampas* A. Agass., are represented in the West Indian deep sea. It is not improbable that they will prove to occur also in the North-eastern Atlantic, but as yet they have not been found there, and therefore cannot be included here.

1. *Neolampas* A. Agassiz.

Test elongate. Ambulacra simple, not petaloid on upper side and only slightly so at the peristome. Mouth more or less anterior. Anal opening at the posterior end of test, in a small depression, above which the test forms a small prominent edge.

Only one species in the British (and European) seas.

1. *Neolampas rostellata* A. Agassiz. (Fig. 184.)

Test low ; on the upper side the posterior interambulacrum forms a rather distinct keel ; on the under side distinctly sunk

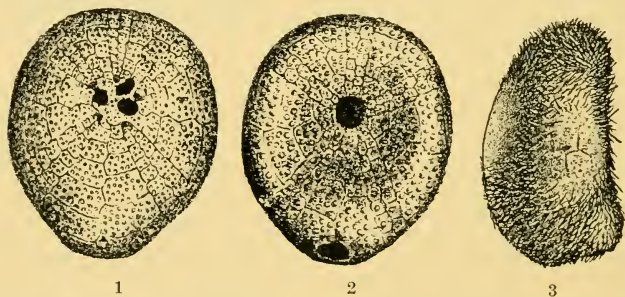


FIG. 184.—*Neolampas rostellata*. $\times 3$. (1-2. After Agassiz, "*Blake*" *Echini*. 3. After Wyv. Thomson, "*Porcupine*" *Echinoidea*.)

1. Denuded test, from above. 2. Same, from below. 3. Side view of specimen with the spines partly preserved.

towards the mouth. Only 3 genital pores ; in the male they are of about the same size as the ocular pores, in the female they are much larger. Only few pores in the madreporite. Colour in life unknown. Apparently not exceeding ca. 20 mm. length.

¹ It is not unlikely that the recent forms known of this order ought rather to be referred to different families. This question, however, cannot yet be regarded as sufficiently elucidated.

Biology unknown. Development unknown, but the large size of the female genital pores indicates large, yolk-y eggs and therefore direct development, without a pelagic larval stage.

A single specimen of this species was dredged by the "Porcupine" at the mouth of the English Channel (48° 31' N., 10° 3' W., 1240 m.); it is thus not found within the British area proper, but as there is every reason to expect that it will occur also off the west coasts, and since the species is included in the lists of British echinoderms given by Hoyle and Bell, it has been thought desirable to include it in the present work. It is known elsewhere from off the coast of Portugal and Morocco, and from the Mediterranean; further it occurs in the West Indian seas (from where the species was first known, and where it appears to be rather common). Bathymetrical distribution ca. 145-1240 m.

V. Order. SPATANGOIDEA

Test elongate, not flattened. Mouth anterior, anal opening posterior. No gills or gill-cuts at peristomial edge of test. No internal supporting system of pillars. No dental apparatus. Ambulacra simple or petaloid on the upper side and usually slightly widened at the mouth. Posterior interambulacrum different from the other interambulacra on the oral side, usually more or less modified so as to form a "sternum" or "plastron"; the first plate of the posterior interambulacrum often specially developed into a prominent "labrum". Tubercles perforate. Spines of various length, those on the plastron often widened into a spade-shape. Often distinct bands of very small, close-set spines, the "fascioles". Tube-feet confined to the ambulacra, usually very diversified, those around the peristome penicillate. Pedicellariæ often very conspicuous; besides the usual four types, a fifth form, the "rostrate" pedicellariæ (Fig. 199, 3), also occurs. Sphæridia present, not in grooves.

This large order is divided into two suborders, both of which are represented in the British seas.

Key to the suborders of the Spatangoidea.

First pair of plates in posterior interambulacrum placed side by side ("amphisternous") (Fig. 185, 1) . I. *Amphisternata*

First pair of plates in posterior interambulacrum placed one behind the other ("meridosternous") (Fig. 185, 2) II. *Meridosternata*

I. Suborder. AMPHISTERNATA Lovén.

First pair of plates in posterior interambulacrum placed side by side, not one behind the other, often much larger than the

other plates, forming a sort of ventral shield, a "sternum" or a "plastron" (Fig. 185, 1). Fascioles usually well developed.

The *fascioles* are very diversified within this suborder and are of great importance for the classification. The following forms of fascioles are distinguished: "*peripetalous*", which surrounds the whole of the petals on the upper side (Fig. 200, 1); "*inner*", surrounding only the anterior ambulacrum on the upper side (Fig. 194); "*lateral*", issuing from the peripetalous fasciole and running along the sides of the test backwards under the peri-

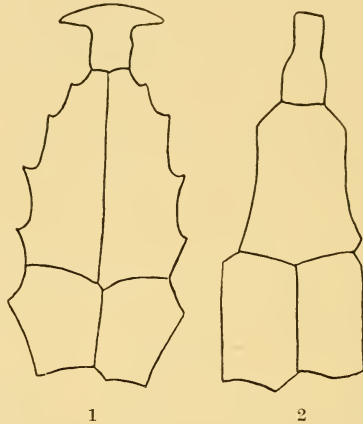


FIG. 185.—Amphisternous (1) and meridosternous (2) type of sternum (or "plastron").

1. Of *Spatangus purpureus* ($\times 3$). 2. Of *Urechinus naresianus* ($\times 6$).

proct (Fig. 189); "*subanal*", forming a closed ring below the periproct and enclosing a certain number of penicillate tube-feet (Fig. 200, 2); "*marginal*", running all round the test at the margin. The small spines ("clavulæ") of which these fascioles consist are very strongly ciliated.

The forms belonging to this suborder have been divided (Clark) into five families, two of which are represented in the British seas, while two more are very likely to occur there also.¹

¹ The fifth family, the *Palæostomatidæ*, contains only a single, small species, *Palæostoma mirabile* Gray, from the Indo-Malayan region.—It may be questionable whether the families of the *Amphisternata* are quite natural, but for the present this classification may be accepted as the best and most practical.

Key to the families of Amphisternata known from or likely to exist in the British seas.

1. Peristome circular,¹ first plate of posterior interambulacrum not forming a labrum Fam. *Aëropsidæ*
 Peristome transversely elongate; first plate of posterior interambulacrum usually forms a labrum 2
2. Ambulacra not petaloid Fam. *Palæopneustidæ*
 „ petaloid 3
3. Subanal fasciole wanting I. Fam. *Hemiasteridæ*
 „ „ present II. Fam. *Spatangidæ*

[Fam. AËROPSIDÆ]

This family comprises some peculiar small deep-sea forms characterised mainly by the primitive structure of the peristome, which is circular, covered by a membrane containing some few scattered plates or none. The first plate of the posterior interambulacrum is not modified so as to form a prominent labrum. A peripetalous fasciole is present. The tube-feet of the frontal ambulacrum very large, with an expanded disk.

The two genera known both occur in the Atlantic, viz. *Aëropsis* Mrtsn. (Syn. *Aërope* Wyv. Thomson), with the species *A. rostrata* (Wyv. Thomson),² and *Aceste* Wyv. Thomson, with the species *A. bellidifera* Wyv. Thomson. *Aëropsis rostrata* has been found in the Davis Strait ("Ingolf"), and off the east coast of N. America ("Challenger"), in depths of ca. 2230-3150 m. It has also been recorded from the Bay of Biscay and off the Portugal coast, but these localities are scarcely reliable. *Aceste bellidifera* was found off the Canaries, 1116 m. ("Challenger"), and off the Azores, 1360 m. ("Princesse Alice").

The two genera are thus distinguished³:

Test elongate, more or less cylindrical; peristome flush with ventral surface; frontal ambulacrum not deepened . . . *Aëropsis* Mrtsn.
 Test wide and flattened; peristome vertical; frontal ambulacrum greatly enlarged and depressed . . . *Aceste* Wyv. Thoms.

¹ The circular peristome is an embryonic character, found also in the newly metamorphosed young of other Spatangoids, but in these latter it very soon (in specimens of 2-3 mm. length) begins to assume the characteristic transversely elongate shape, whereas in the Aëropsidæ it retains the round shape throughout life.

² H. L. Clark gives A. M. Norman as author of the name *Aërope rostrata*, but as Norman himself gives Wyv. Thomson as author of the name, the fact that Norman's description antedates Wyv. Thomson's by some months would not seem to justify depriving Wyv. Thomson of this honour.

³ For detailed descriptions and figures of the two species see "Ingolf" *Echinoidea*, ii., p. 90, Pls. V., XV.; "Challenger" *Ech.*, pp. 192, 195, Pls. XXXII., XXXIII.

[Fam. PALÆOPNEUSTIDÆ]

The various deep-sea genera united into this family agree with the Spatangoids proper in having the peristome transversely elongate and the first plate of the posterior interambulacrum modified into a more or less prominent labrum, but differ from the other Spatangoids in the ambulacra being simple on the dorsal side, not petaloid widened, or, when slightly petaloid in larger specimens, not sunk.¹

Two genera are known from the N.E. Atlantic and may be expected to occur also in the British seas, namely *Palæotropus* Lovén and *Peripatagus* Koehler. Of the former, one species, *Palæotropus Josephinæ* Lovén (Syn. *Palæobrissus Hilgardi* A. Agassiz; *Palæotropus hirondellei* Koehler),² has been found in the Bay of Biscay and off the Azores ("Josefina", "Hirondelle", "Princesse Alice"), in depths of 500-1600 m.; also found in the West Indies. Of *Peripatagus* only a single species is known, namely *P. cinctus* Koehler, found off the Azores, 880-1494 m. ("Hirondelle", "Princesse Alice"). The two forms are thus distinguished:

A subanal fasciole present (obliterating in the larger specimens);	
no marginal fasciole	<i>Palæotropus</i> Lovén
No subanal fasciole; a marginal fasciole present	<i>Peripatagus</i> Koehler

Detailed descriptions and figures of these two forms are given by Koehler ("*Monaco*," Fasc., xii., p. 29, Pls. V., VI.; Fasc. xxxiv., p. 248, Pl. XXXI.), A. Agassiz ("*Blake*" *Echini*, pp. 53, 56, Pls. XXIII., XXIV.), as also by Lovén (*Études sur les Échinoidées*, p. 17, Pl. XIII.).

I. Family HEMIASTERIDÆ

Ambulacra on upper side of test petaloid widened and more or less sunk; first plate of posterior interambulacrum developed into a prominent lip partly covering the mouth and the transversely elongate peristome. No closed subanal fasciole.

Two genera represented in the British seas; a third genus,

¹ The family is not well defined, but as far as the N.E. Atlantic forms are concerned there is no trouble in recognising them as different from the true Spatangoids (the families Hemiasteridæ and Spatangidæ).

² H. L. Clark is responsible for making *Palæobrissus Hilgardi* and *Palæotropus hirondellei* synonyms of *Palæotropus Josephinæ*; the present author has had no opportunity for a closer study of these forms.

Schizaster L. Agass., is represented in the Mediterranean by the species *canaliferus* (Lamarek)—perhaps rather to be regarded as the type of a separate genus, *Ova* Gray, and thus to be designated *Ova canalifera* (L. Agass.); even though it may probably be found also along the Atlantic coasts of Morocco and Spain, there is no probability of its extending north to the British area. It is related to *Brisaster*, but easily recognisable by its high, vertical posterior end, two genital pores, and the crowded pores of the frontal ambulacrum, arranged in double series.

*Key to the genera of Hemiasteridæ known from the British
(and N.E. Atlantic) seas.*

Only a peripetalous fasciole present; test high; frontal ambulacrum narrow, only slightly deepened

1. *Hemiaster* Ag. and Desor

A lateral fasciole issues from the peripetalous fasciole; test low; frontal ambulacrum very broad and much deepened

2. *Brisaster* Gray

1. *Hemiaster* L. Agassiz and Desor.

Test rather high, scarcely elongate. A conspicuous, nearly circular peripetalous fasciole, but no other fascioles. Frontal ambulacrum narrow, scarcely deeper than the lateral petals. Four genital pores. The madreporite not prolonged backwards so as to separate the posterior genital and ocular plates (Fig. 188, 1), the apical system being of the "ethmophract" type.

Only one species of this genus known from the British (and N.E. Atlantic) seas.

1. *Hemiaster expergitus* Lovén. (Fig. 186.)

(Syn. *Hemiaster zonatus* A. Agass.; *H. Mentzii* A. Agass.;
H. gibbosus A. Agass.)

Test nearly round, high, but flattened above, gently rising towards the posterior end, which is vertical. Petaloid area small, the surrounding peripetalous fasciole rather distant from the ambitus. The posterior paired petals about half as long as the anterior ones. The sternum very wide, the width distinctly more than half the length. Valves of globiferous pedicellariæ ending in a transverse-oval opening surrounded by usually 6 teeth (Fig. 187, 1). Colour in life unknown, but probably yellowish-brown. Largest size recorded, 53.5 mm. length.

It is a very fragile form, which must be assumed to live buried in the soft deep-sea mud. Development unknown.

In British seas this species has been found in fair numbers off

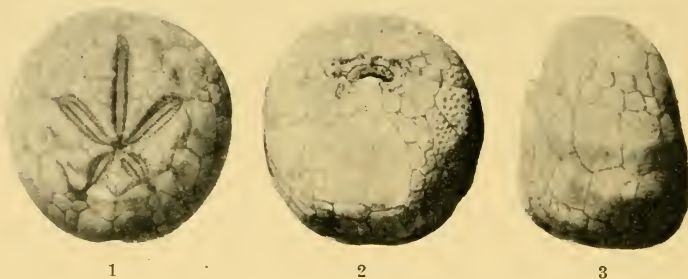


FIG. 186.—*Hemiaster expergitus*; naked test, seen from above (1), from below (2), and in side view (3). Nat. size. (After Th. Mortensen, "Ingolf" *Echin.*, ii.)

the west coast of Ireland ("Helga"), in ca. 940-1770 m. It is further known from off the Norwegian coast ($61^{\circ} 40' \text{ N.}$, $3^{\circ} 11' \text{ E.}$)¹ and S. of Iceland to the Azores and Cape Verde Islands, and

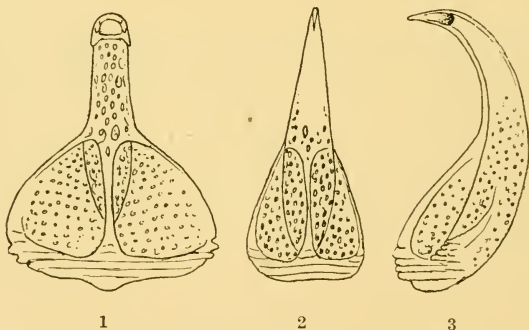


FIG. 187.—Valves of globiferous pedicellariæ of *Hemiaster expergitus* (1) and *Brisaster fragilis* (2-3). $\times 50$. (After Th. Mortensen, "Ingolf" *Echin.*, ii.)

1 and 2. From the inside. 3. In side view.

from the Davis Strait to the West Indies, in depths of ca. 400-3120 m. Also in the Pacific, as the form described from there under the name of *Hemiaster gibbosus* A. Ag. seems to be indistinguishable from *H. expergitus*.

¹ This locality seems rather extraordinary for an Atlantic deep-sea form and may perhaps be due to erroneous labelling; at least it may be regarded as uncertain until the species has been found there again.

2. *Brisaster* Gray.

Test low, elongate. From the sides of the peripetalous fasciole proceeds a lateral fasciole, running backwards, below the periproct. Frontal ambulacrum very broad and deep. Three genital



FIG. 188.—Apical system of *Hemiaster expergitus* (1) and *Brisaster fragilis* (2). (After Th. Mortensen, “Ingolf” *Ech.*, ii. (1) and Lovén, *Études sur les Échinodées* (2).)

pores. Madreporite prolonged backwards so as to separate the posterior genital and ocular plates (Fig. 188, 2), the apical system being of the “ethmolytic” type.

Only one species of this genus known from the British (and N.E. Atlantic) seas.

1. *Brisaster fragilis* (Düben and Koren). (Fig. 189.)

(Syn. *Brissus*, *Tripylus*, *Schizaster fragilis* (Düb. and Kor.).)

Test low, but rising gently towards the posterior end; a deep notch in the anterior end, on account of the deepened frontal ambulacrum. Anterior paired petals about three times as long as the posterior ones. Posterior interambulacrum usually raised so as to form a fairly distinct keel on the upper side. Apical system posterior to the middle of the test. No genital pore in the madreporite, thus only one genital pore in the right, two in the left side. Usually the right, more rarely the left side of the test somewhat projecting beyond the other. The lateral fasciole is rather often indistinct, but the part of it below the anal area is usually quite distinct. Globiferous pedicellariæ usually rather conspicuous, enclosed by a thick, often dark pigmented skin; the valves (Fig. 187, 2-3) are very characteristic in having a single end tooth, at the side of which the opening of the poison gland is found. Colour in life a dark brownish, which usually keeps well in alcohol. Reaches a size of up to 90 mm. length of test.

It is a rather fragile form, which lives on a soft mud bottom; its intestine is filled with mud, the organic substances in the mud

thus forming its food. Development unknown, but the large, yolky eggs indicate that it has direct development, without a pelagic larval stage.

In British seas this species has been found only in the Faroe

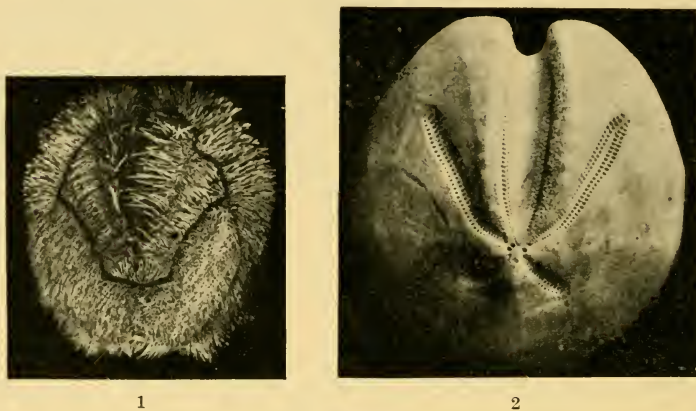


FIG. 189.—*Brisaster fragilis*. (1. From *Danmark's Fauna*.)

1. Specimen with the spines preserved, showing the peripetalous and lateral fascioles.
2. Naked test. Both from above; nat. size.

Channel, N. and W. of Shetland, 720-900 m. ("Porcupine"). It is elsewhere distributed along the Norwegian coast, from Bergen to Finmark, S. and W. of Iceland, and from the Davis Strait to Florida. Bathymetrical distribution ca. 65-1300 m.

II. Family SPATANGIDÆ

Ambulacra on upper side of test petaloid, widened, and more or less sunk; first plate of posterior interambulacrum developed into a prominent lip, partly covering the mouth and the transversely elongate peristome. A closed subanal fasciole present.

Three genera represented in the British seas; two more genera are represented in the Mediterranean and the N.E. Atlantic, namely *Brissus* Leske and *Plagiobrissus* Pomel. Of the former, the species *Br. brissus* (Leske) (Syn. *Brissus unicolor* Klein) is distributed from the Mediterranean to the Cape Verdes, the Azores, St. Helena, and the West Indies, in depths of ca. 10-240 m.; of the latter, the species *Plagiobrissus Costæ* (Gasco) (Syn. *Metalia Costæ* Gasco) is known only from the Mediterranean, but may well be expected to extend also to the Atlantic; it is known from depths of ca. 25-150 m. There is hardly any

probability of these two forms occurring so far north as the British area.¹

Key to the genera of Spatangidae represented in the British seas.

1. Only a subanal fasciole present

1. *Spatangus* (Klein) O. Fr. Müll.

Besides the subanal fasciole also a peripetalous or an inner fasciole present 2

2. An inner fasciole present 2. *Echinocardium* Gray

A peripetalous fasciole present 3. *Brissopsis* L. Agass.

1. *Spatangus* (Klein) O. Fr. Müller.

(Heart-urchin.) (Syn. *Prospatangus* Lambert.)

Only a subanal fasciole present. The widened part of the lateral ambulacra on upper side of test (the "petals") scarcely deepened. Frontal ambulacrum rather deep, forming a conspicuous broad notch in anterior edge of test. Four genital pores. Large, robust forms, usually somewhat unsymmetrical, the right side projecting beyond the left.

Two species in the British seas. A third species, *Spatangus inermis* Mrtsn., is known from the Mediterranean; it may well be expected to occur also off the adjoining Atlantic coasts, but there is scarcely any probability of its occurring as far north as the British coasts. This species is easily distinguished from the other *Spatangus* species by lacking the large tubercles on the upper side, excepting a very few in the middle of the posterior interambulacrum and on the sides of the frontal ambulacrum.²

Key to the species of Spatangus known from the British seas.

Test low; subanal area about three times as broad as long

1. *Sp. purpureus* O. Fr. Müll.

Test high; subanal area not twice as broad as long

2. *Sp. Raschi* Lovén

¹ Descriptions and figures of these two forms are found in Koehler's *Échinodermes, Faune de France*, p. 133 (*Brissus unicolor*), and Th. Mortensen, *Die Echiniden des Mittelmeeres* ("Mitt. Zool. Stat. Neapel," 21, 1913, p. 32, Taf. 3, 5 (*Plagiobrissus* (*Metalia*) *Costæ*).

² Full description and figures of this species are given in Th. Mortensen, *Die Echiniden des Mittelmeeres* ("Mitt. Zool. Stat. Neapel," 21, 1913, p. 24, Taf. 1).

1. *Spatangus purpureus* O. Fr. Müller. (Fig. 190.)(Syn. *Spatangus meridionalis* Risso.)

Test broad, rather low, regularly arched on the upper side, flat on the under side ; the mouth not much sunk. Labrum broadly rounded (Fig. 192, 2). The area included by the subanal fasciole very broad, ca. three times as broad as long (Fig. 193). Fairly numerous large tubercles (spines) in the interambulacra on the upper side of the test, but not in the ambulacra outside the petaloid part. Colour violet, the long curved spines of the upper



FIG. 190.—*Spatangus purpureus* ; naked test, from above. Nat. size.

side lighter coloured, often whitish. The colour does not fade in alcohol. Reaches a very considerable size, up to ca. 120 mm. in length.

It prefers a rather coarse sand or gravel bottom, in which it lies wholly buried. The food consists of all sorts of bottom particles and organisms (*e.g.* *Echinocyamus pusillus*), which it picks out by means of its penicillate oral tube-feet. A form living on muddy bottom (type locality off Lowestoft) is more concave on the oral side than usual in the typical form and has been distinguished as a separate variety, the Var. *concava* Klinghardt ; very probably this is, however, only an abnormal form,

a monstrosity (cf. *Echinocardium flavescens* and *Brissopsis lyrifera*). A large form from the Mediterranean with unusually broad petals corresponds to the fossil (post-Pliocene) *Spat. di Stefanoi* Checchia-Rispoli, and may be distinguished as a separate variety under this name; it may perhaps also be found in the British seas (cf. Th. Mortensen, *Die Echiniden des Mittelmeeres*, p. 22, Taf. 2, 1).

A small bivalve mollusc, *Montacuta substriata* Montagu, is sometimes found attached to the spines of this Spatangoid.

The breeding season is in the summer months. The larva (Fig. 191) is characterised by its exceedingly long posterior process. Postero-lateral rods simple with only a few thorns. *Hybrids* between this and the following species appear to be not very rare.

In British seas this species occurs all round the coasts, in places at least very common, so that great numbers may be taken in a single haul; also recorded from the Rockall Bank. It is elsewhere distributed from North Cape to the Azores and the Mediterranean, but is not found at Greenland or the Atlantic coasts of N. America. The bathymetrical distribution is from lowermost tide limit to ca. 900 m.

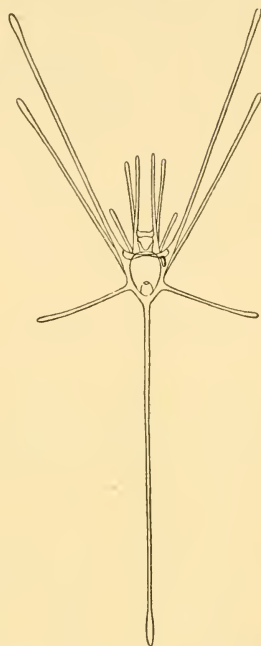


FIG. 191.—Larva of *Spatangus purpureus*. $\times 25$.
(From *Danmark's Fauna*.)

2. *Spatangus Raschi* Lovén. (Figs. 192, 193.)

(Syn. *Spatangus meridionalis* Norman, non Risso.)

Test high, rising rather abruptly from the anterior end. Mouth rather deeply sunk, labrum prominent (Fig. 192, 1). Area enclosed by the subanal fasciole not twice as broad as long (Fig. 193); the fasciole sometimes indistinct, may even totally disappear. Large tubercles (spines) of the upper side not so conspicuous as in *purpureus*, occurring also in the ambulae between the petals and the ambitus. Colour deep violet-purple. Reaches about the same size as *purpureus*.

Appears to belong more to the mud bottom than does *S. purpureus*. Development unknown.

In British seas this species is stated to be by far the most

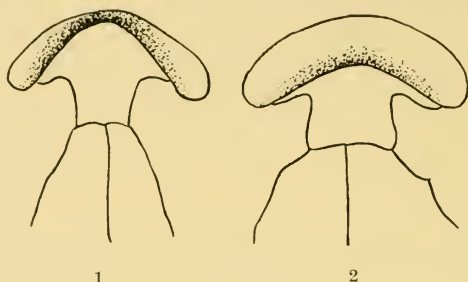


FIG. 192.—Labrum of *Spatangus Raschi* (1) and *Sp. purpureus* (2).

abundant echinoderm off the west coast of Ireland in depths of ca. 150-1000 m. Also found off the Shetland Islands and at the Lousy Bank, but not known from the North Sea coasts, the Irish

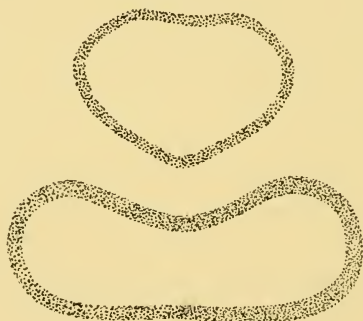


FIG. 193.—Subanal fasciole of *Spatangus Raschi* (upper figure) and *Sp. purpureus* (lower figure). Slightly enlarged.

Sea, or the south coasts. It is elsewhere distributed from Tromsö on the coast of Norway to the Bay of Biscay and the Azores, but not found in the Mediterranean nor on the east coast of N. America. Bathymetrical distribution ca. 150-1000 m.

2. *Echinocardium* Gray.

(Syn. *Amphidetes* L. Agassiz.)

Besides the subanal fasciole an inner fasciole is present, surrounding only the frontal ambulacrum and the apical system. Often a trace of a fasciole is seen issuing from the subanal

fasciole, running upwards on each side the periproct. Four genital pores. Smaller, fragile forms, usually of yellowish colour.

Three species are found in the British seas. Two more species are found in the Mediterranean, namely *Ech. mediterraneum* Forbes and *Ech. Mortenseni* Thiéry (Syn. *Echinocardium intermedium* Mrtsn.); while the latter is known hitherto only from the Mediterranean, the former goes as far north as the Bay of Biscay (Santander); there may then perhaps be a possibility of its occurring also off the British south coasts, and it may be desirable to include both these species in the key, referring for the detailed description and figures of them to Koehler's *Échinodermes, Faune de France*, pp. 135, 137.

*Key to the species of Echinocardium known from or possibly
occurring in the British seas.*

1. Frontal ambulacrum deepened 2
- " " flush with the test 3
2. The furrow of the frontal ambulacrum continuing to the apical system; the pores within the inner fasciole in close, double series. Larger tubercles are found scattered on the anterior interambulacra above the ambitus 1. *Ech. cordatum* (Penn.)
- The furrow ends abruptly at the anterior end of the inner fasciole; pores within the fasciole distant, in single series. No larger tubercles above the ambitus *Ech. mediterraneum* Forb.
3. No larger tubercles in the interambulacra above the ambitus; labrum very short, not reaching beyond the middle of the first adjoining ambulacral plates (Fig. 196, 1)

3. *Ech. pennatifidum* Norm.

Larger primary tubercles found at least in the anterior interambulacra above the ambitus; labrum generally reaching the second adjoining ambulacral plates (Fig. 196, 2) . . . 4

4. Larger tubercles in all the interambulacra above the ambitus, rather prominent . . . 2. *Ech. flavescens* (O. Fr. Müll.)
- Larger tubercles only in the anterior interambulacra above the ambitus, not very prominent . . . *Ech. Mortenseni* Thiéry

1. *Echinocardium cordatum* (Pennant). (Fig. 194, 1-2.)¹

(Syn. *Amphidetus* (*Amphidotus*) *cordatus* (Penn.).)

Frontal ambulacrum rather deeply sunk, the furrow continuing from the anterior end to the apical system; the pores within the inner fasciole very close, partly forming irregular double series. Test somewhat sloping anteriorly, the greatest

¹ A good figure of a denuded test of a large *Echinocardium cordatum* is found in Bell's *Catalogue Brit. Ech.*, Pl. XVI., 1; the figure is, however, incorrect in representing the internal fasciole open in front.

height about midway between the apical system and the posterior end, the posterior interambulacrum being rather elevated. The paired interambulacra with a number of somewhat larger tubercles above the ambitus, and with corresponding longer spines among the general short, uniform covering of spines; these longer spines are, however, less conspicuous than the larger tubercles on the denuded test. The labrum reaches to the second adjoining ambulacral plates. The pedicellariæ partly very characteristic; the globiferous—which have been found only in specimens from the Mediterranean—are very conspicuous, with a thick, brownish head and a thick stalk with a whorl of freely projecting rods (Fig. 195, 2); the valves have 5-6 teeth along each side of the terminal opening. The tridentate pedicellariæ (Fig. 195, 1) have leaf-shaped valves, with the edges of the lower part of the blade

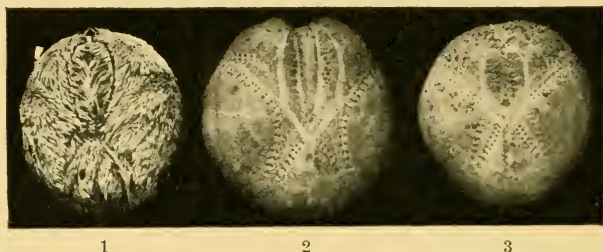


FIG. 194.—1-2. *Echinocardium cordatum*, upper side; 1, covered with its spines; 2, the denuded test. 3. *Echinocardium flavescens*; denuded test, upper side. The figures show the inner fasciole distinctly. Slightly reduced in size. (From *Danmark's Fauna*.)

irregularly serrate; the triphyllous pedicellariæ (Fig. 197, 1) have a series of broad teeth inside the edge. Reaches a size of ca. 90 mm. length of test.

Lives mainly on sandy bottom, buried ca. 15-20 cm. deep in the ground; a channel leads from the hole to the surface of the ground. The slime secreted by the spines glues the sand grains together, the animal lying free in the hole, not directly in touch with the sand. It is said to take the food particles from the surface of the sand by means of the exceedingly extensile tube-feet of the frontal ambulacrum, which drag them down into the hole to the under side of the animal, where the penicillate tube-feet around the mouth catch the particles and put them into the mouth. In any case the opinion held formerly that this species, and the Spatangoids generally, get their food by the bottom material being automatically pushed into the mouth as the animal bores through the sand does not hold

good; this view can at most be true to a limited extent for the species living in soft mud. Very probably it does not lie for a long time in its hole, but must leave it now and then (during night probably) and dig itself a new hole; otherwise it is hardly conceivable that it could get sufficient food, as the surface round the hole in the area within reach to the tube-feet could hardly avoid being soon exhausted of food particles.¹ The species lives rather gregariously and is one of the characteristic forms of some marine animal communities.

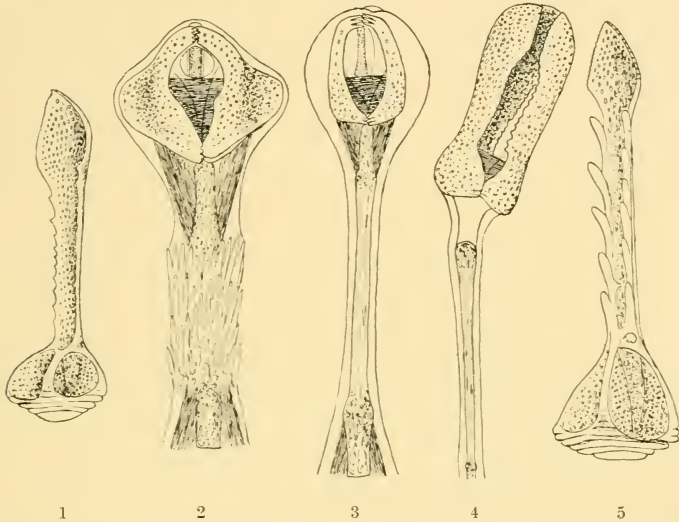


FIG. 195.—1. Valve of tridentate pedicellaria; 2. Globiferous pedicellaria of *Echinocardium cordatum*. 3. Globiferous pedicellaria; 4. Tridentate pedicellaria of *Echinocard. flavescens*. 5. Valve of tridentate pedicellaria of *Echinocard. pennatifidum*. 1-4, $\times 27$; 5, $\times 36$. (After Th. Mortensen, "Ingolf" *Ech.*, ii.)

The breeding season is in the summer-time. The larva (Fig. 3, 4) has strongly thorny postero-lateral rods; the posterior process exceedingly variable in length, sometimes a mere short stump, sometimes as long as the postoral arms. Point of arms and of posterior process conspicuously red. The larvæ are sometimes found in enormous numbers and likewise the young, newly metamorphosed young may be found in enormous numbers in some places, and thus may be of importance as fish food, as young *Spatangoids* in general are eaten by various kinds of fishes.—The different species of *Echinocardium* may be

¹ This is merely a suggestion, as yet not supported by direct observations.

distinguished with full certainty by means of their triphyllous pedicellariæ already in the quite young stages before the specific characters of the test have appeared, the triphyllous pedicellariæ appearing very soon after metamorphosis and as the first of all the pedicellariæ.

A small Amphipod, *Urothoë marina* Sp. Bate, lives as a commensal with this sea-urchin in its hole.

In British seas this species is very common all round the coasts. It is mainly a littoral form, and may in several places be dug up from the sand at low tide. Its distribution elsewhere is very wide, cosmopolitan, the forms living at S. Africa, Australia, New Zealand, Japan, etc. being scarcely distinguishable from the European form. In the European seas it occurs from Tromsö to the Sound on the Scandinavian coasts, and from the British seas to the Mediterranean. It is, however, not known from Iceland or Greenland. Bathymetrical distribution, 0-ca. 230 m.

2. *Echinocardium flavescens* (O. Fr. Müller). (Fig. 194, 3.)

(Syn. *Echinocardium ovatum* Gray ; *Amphidetus ovatus* (Leske) ; *Amph. roseus* Forbes.)

Frontal ambulacrum not sunk, the anterior end of test rounded or at most with a very slight notch. Pores of frontal ambulacrum within the fasciole distant, in regular single series. Test not sloping anteriorly, almost vertical before the fasciole ; the greatest height usually at the anterior edge of the fasciole. A variable number of larger tubercles (spines)¹ in the paired inter-ambulacra above the ambitus. Labrum somewhat prolonged backwards, reaching to the middle of the adjoining second ambulacral plates (Fig. 196, 2). The globiferous pedicellariæ (Fig. 195, 3), which are usually fairly numerous and conspicuous, darkly pigmented or yellow, have a slender stalk, without free projecting rods ; the valves usually have 6-8 long, slender teeth at the terminal opening ; the tridentate pedicellariæ (Fig. 195, 4) are in the main like those of *cordatum*, the triphyllous (Fig. 197, 2) have the edge of valves nearly smooth, with only a few serrations at the base. Colour in life yellow or rose. Reaches scarcely as large a size as the preceding species.

The biology of this species has not been closely studied, but very probably it is like that of *Ech. cordatum*, although it

¹ It is sometimes very difficult to distinguish these larger spines ; on denuding the test of such specimens one may find the grooves in which the larger spines have been attached, the spines having for some reason or other been lost and replaced by new, much smaller spines.

scarcely occurs within tide limits, as does that species. Development unknown. It appears that the breeding season is in the early summer months.

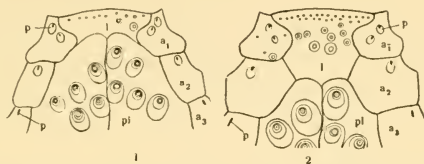


FIG. 196.—Proximal end of posterior interambulacrum and the adjoining ambulacral plates of *Echinocardium pennatifidum* (1) and *Ech. flavescens* (2). $\times 3$. (From *Danmark's Fauna*.)

a₁₋₃, Ambulacral plates Nos. 1-3; l, Labrum; p, Pores of tube-feet; pl, Plastron or sternum.

Monstrous specimens of this species, often of quite fantastical shapes, occur not very rarely, *e.g.* in Skagerrack (cf. *Brissopsis lyrifera*).

In British seas this species apparently occurs all round the coasts, in places very common, though scarcely so much so as

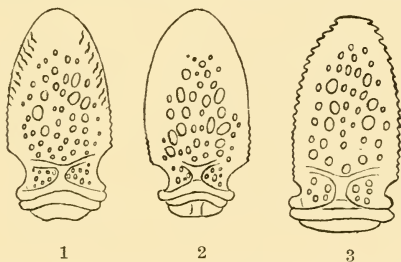


FIG. 197.—Valves of triphyllous pedicellariæ of *Echinocardium cordatum* (1), *Ech. flavescens* (2), and *Ech. pennatifidum* (3). $\times 200$. (After Th. Mortensen, "*Ingolf*" *Ech.*, ii.)

the preceding species, and usually not together with that species. It is elsewhere distributed from Finmark and Iceland to the Azores and the Mediterranean. Not known from Greenland, and the record of its occurrence on the east coast of N. America needs verification. Bathymetrical distribution ca. 5-325 m.

3. *Echinocardium pennatifidum* Norman. (Fig. 198.)

(Syn. *Amphidetus gibbosus* Barrett; non Agass.¹)

Frontal ambulacrum not sunk, anterior end of test rounded, at most with a very slight indication of a notch. Pores of frontal

¹ The *Amphidetus gibbosus* Agass., with which the present species was identified by Barrett, who first discovered it, is a synonym of *Echinocard. mediterraneum*.

ambulacrum, within the fasciole, distant, in regular single series. Test rather flattened above, scarcely rising posteriorly, gently rounded at the anterior end. No larger tubercles (spines) in the interambulacra above the ambitus. Labrum very short, not reaching beyond the middle of the first adjoining ambulacral plates (Fig. 196, 1). The globiferous pedicellariæ, which are usually not very numerous, are mainly like those of *cordatum*, but the stalk is without free projecting rods; the tridentate pedicellariæ (Fig. 195, 5) are very characteristic, the valves with strongly serrate edges. (This form, which is very conspicuous, reaching a size of ca. 2.5 mm. length of head, has given rise to the specific name *pennatifidum*; other smaller forms of tridentate

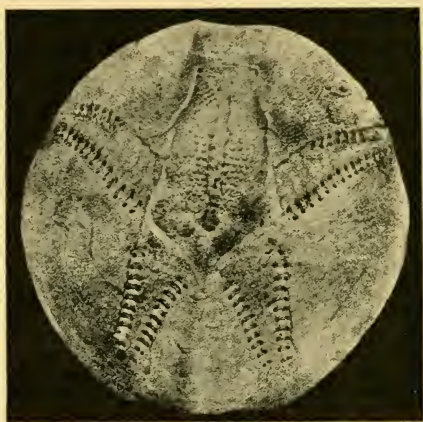


FIG. 198.—*Echinocardium pennatifidum*; naked test, from above. Nat size. (After Koehler, *Faune de France*.)

pedicellariæ, with more simple, leaf-shaped valves, occur in both this and the other species of the genus.) The triphyllous pedicellariæ (Fig. 197, 3) are finely serrate along the whole edge of the blade. Reaches a large size, up to 70 mm. length.

Biology apparently the same as that of *cordatum*; very common within the tide limits at the Channel Islands (Herm). Development unknown. Appears to form hybrids with *Ech. flavescens*.

In the British seas this species has been found, though nowhere in larger numbers, on the south, west, and north coasts, and down to Durham on the east coast; it has also been taken on the "Porcupine" Bank (165 m.). It is elsewhere distributed from the coast of Norway (Haugesund) to the Mediterranean,

but is not known from Iceland, Greenland, or the east coast of N. America. Bathymetrical distribution, 0-ca. 260 m.

3. *Brissopsis* L. Agassiz.

Besides the subanal fasciole a peripetalous fasciole is present, encircling the whole of the widened ambulacra (petals) on the upper side. Frontal ambulacrum more or less deepened. Four genital pores. Forms of moderate size, with rather fragile test.

Only one species known from the British seas, but a second species, *Brissopsis atlantica* Mrtsn., may be expected to occur

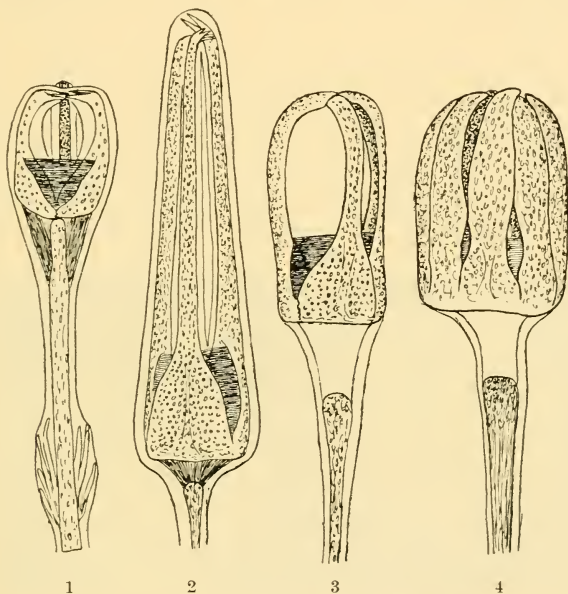


FIG. 199.—Globiferous pedicellaria of *Brissopsis lyrifera* (1); slender form of globiferous pedicellaria of *Briss. atlantica* (2); rostrate pedicellaria of *Briss. lyrifera* (3); 8-valved pedicellaria of *Briss. atlantica* (4). 1, $\times 16$; 2, $\times 35$; 3, $\times 30$; 4, $\times 40$. (After Th. Mortensen, "Ingolf" *Ech.*, ii.)

in the deep sea off the west coasts, this species having been found at $37^{\circ} 52' N.$, $9^{\circ} 15' 45'' W.$, 552 m. ("Princesse Alice"), and also in the Mediterranean; it is found elsewhere off the east coast of N. America and in the West Indies, in depths of ca. 125-2440 m. The Mediterranean form has been distinguished as a separate variety, *Var. mediterranea* Mrtsn.¹

¹ For a full description and figures of *Brissopsis atlantica* see Th. Mortensen, "Ingolf" *Echinoidea*, ii., p. 160, and the same author's *Die Echiniden d. Mittelmeeres*, p. 29.

The two species may be thus distinguished :

Posterior petals diverging, well separated ; globiferous pedicellariæ of one kind only, with short valves ending in two long hooks (Fig. 199, 1) ; tridentate pendicellariæ only 3-valved

1. *Br. lyrifera* Forbes.

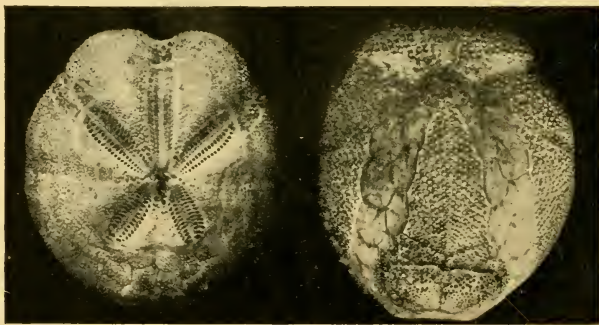
Posterior petals nearly parallel and confluent ; globiferous pedicellariæ of two kinds : one with long, slender valves, terminating in two long hooks (Fig. 199, 2), the other with short valves with 4 small teeth round the terminal opening. Tridentate pedicellariæ occur, besides in the usual 3-valved form, also in a form with 8 valves (Fig. 199, 4)

Br. atlantica Mrtsn.

1. *Brissopsis lyrifera* (Forbes). (Fig. 200.)

(Syn. *Brissus lyrifer* Forbes.)

Test oval, arched, somewhat sloping anteriorly ; the greatest height behind the apical system. Frontal ambulacrum rather deep, forming a conspicuous notch in the anterior end of the test. Posterior petals somewhat shorter than the anterior, diverging,



1

2

FIG. 200.—*Brissopsis lyrifera* ; denuded test, from the upper (1) and under side (2). Nat. size. (From *Danmark's Fauna*.)

not confluent. The peripetalous fasciole very conspicuous, especially on the living animal, and forms a characteristic figure, which has given rise to the specific name. The subanal area encloses 4 ambulacral plates (3 tube-feet), the first of them being No. 6. Globiferous pedicellariæ of only one kind (Fig. 199, 1), rather conspicuous, invested by a thick (in life vividly yellow) glandular skin. The valves are short, ending in two rather long teeth ; the stalk has some long, projecting thorns. The tridentate pedicellariæ of various forms, with more or less leaf-shaped valves,

always with 3 valves, never 8-valved (as in *atlantica*); the rostrate pedicellariæ very slender (Fig. 199, 3); triphyllous pedicellariæ not characteristic. Colour in life mostly red-brown, sometimes fading in alcohol. Reaches a size of ca. 70 mm. length.

It lives gregariously—often in immense numbers—on soft

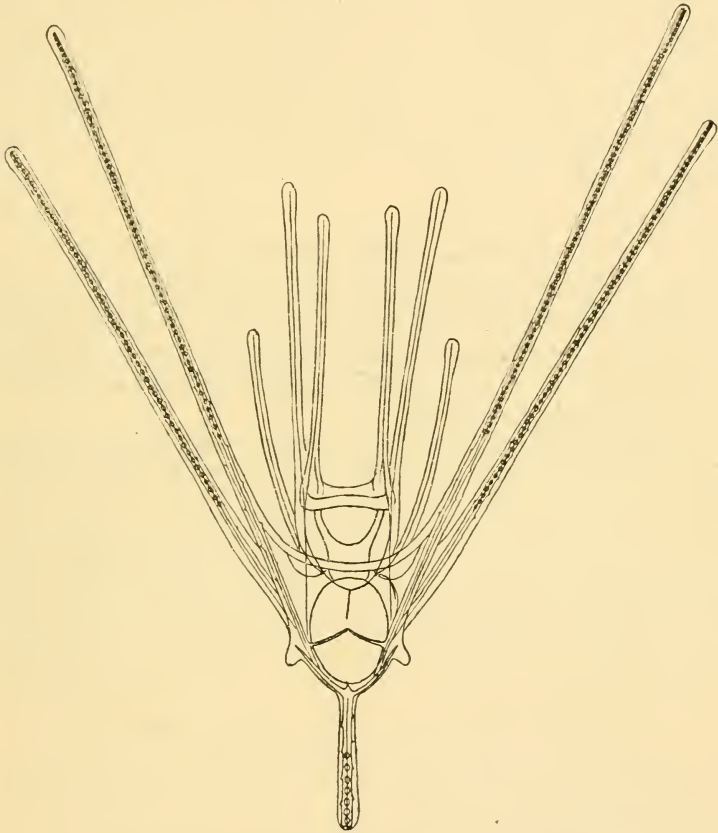


FIG. 201.—Larva of *Brissopsis lyrifera*. $\times 20$.
(From *Danmark's Fauna*.)

mud bottom, lying buried in the ground; it fills its intestine with the mud, subsisting thus on the organic substances and small organisms (especially Foraminifera) found therein. The breeding season is in the summer-time. The larva (Fig. 201) differs from other known Spatangoid larvæ in lacking the postero-lateral arms.

Monstrous, often most fantastically transformed, specimens occur in great numbers in Skagerrack.

In British seas this species is known from all along the west, north, and east coasts, but is not recorded from the south coast. It is elsewhere distributed from Lofoten, on the Norway coast, and Iceland to the Mediterranean and S. Africa. Also on the east coast of N. America, but not known from Greenland. The bathymetrical distribution is ca. 5-365 m., and probably more. It is recorded from depths of ca. 860-1280 m. from off the Irish west coast ("Helga"), and even from 3760 m. ("Porcupine"), but there is no certainty that the specimens from these depths are really *Br. lyrifera*, under which name several different species were hitherto confounded.

II. Suborder. MERIDOSTERNATA Lovén.

First pair of plates in the posterior interambulacrum placed one behind the other, not much larger than the other plates, forming no conspicuous ventral shield or "sternum" (Fig. 185, 2). Pores simple or double. Fascioles not developed or, at most, very small and inconspicuous.

The forms belonging to this suborder are exclusively deep-sea forms, usually very fragile, partly of most extraordinary shape. They are divided into four families, two of which are represented in the British seas; a third, the family *Calymnidae*, of which only one genus and species is known, *Calymne relictæ* Wyv. Thomson, may perhaps also be found there. The species was taken by the "Challenger" north of the Bermudas in 4770 m. (not at the Azores (Fayal), as erroneously stated in the "Challenger" *Echinoidea*).

Key to the families of Meridosternata known from or likely to occur in the British seas.

1. Mouth horizontally placed on oral surface of test; no oral invagination 2
- Mouth vertical, at the end of a deep oral invagination

II. Fam. *Pourtalesiidae*

2. Second plate in the anterior interambulacra paired; a marginal fasciole present¹ Fam. *Calymnidae*
- Second plate in all interambulacra single; no marginal, but usually a subanal fasciole present I. Fam. *Urechinidae*

¹ The presence of a marginal fasciole is probably a character only of generic value; this also applies to the subanal fasciole in *Urechinidae*. For description and figures of *Calymne relictæ* see "Challenger" *Echin.*, p. 154, Pl. XXXIV., and "Ingolf" *Ech.*, ii., p. 53.

I. Family URECHINIDÆ.

Mouth placed horizontally on the oral side of the test; no deep oral invagination. Second plate in all the interambulacra single, the two plates of this number being placed one behind the other ("meridoplacous"), as is the case in the posterior interambulacrum in the whole suborder. The pores all simple. Apical system usually disconnected. A subanal fasciole usually present. Very fragile deep-sea forms, usually of oval shape, covered uniformly with short, simple spines.

One genus, *Plexechinus* A. Agass., known from the British seas; a second genus, *Urechinus* A. Agass., is very likely to occur there also, the species *Urechinus naresianus* A. Agass. being known from the North Atlantic, S. and W. of Iceland, east of N. America, the Mid-Atlantic, and off S. Africa; further from the Indian and Pacific Oceans, the species being thus of quite cosmopolitan distribution. Its bathymetrical distribution is ca. 1450-4480 m.¹

The two genera are thus distinguished:

Periproct in a depression above the ambitus

1. *Plexechinus* A. Agass.

Periproct at or below the ambitus, not in a marked depression

Urechinus Wyv. Thoms.

1. *Plexechinus* A. Agassiz.

Test elongate oval, with a rather prominent "anal snout", above which the periproct is situated in a more or less distinct depression. A subanal fasciole present. Small deep-sea forms.

Only one species known from the British seas (and from the Atlantic in general).

1. *Plexechinus hirsutus* Mrtsn. (Fig. 202.)

The posterior end of test much higher than the anterior, the posterior interambulacrum forming a prominent keel, prolonged into a broad, slightly projecting anal snout, which is surrounded by a fasciole. Four ambulacral plates enclosed by the fasciole. Apical system disconnected, the posterior paired interambulacra uniting in the middle of the test, thus separating the two posterior ocular plates widely from the three anterior ones; in accordance herewith the anterior (frontal) ambulacrum is remarkably

¹ *Urechinus naresianus* is also recorded from a depth of 760 m., but this seems not wholly reliable. For a full description and figures of this species see "*Challenger*" *Ech.*, p. 146, Pls. XXIX., XXX., XXX.A, and "*Ingolf*" *Ech.*, ii., p. 39, Pl. VI., etc.

shortened (Fig. 202, 2). Only 2 genital pores present, situated in the plate joining the anterior ambulacrum; other genital plates cannot be distinguished with certainty. The genital pores are covered by long genital papillæ. Spines numerous, small and

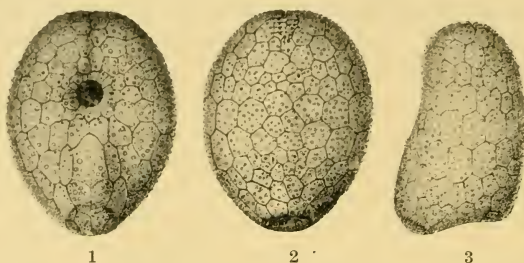


FIG. 202.—*Plexechinus hirsutus*; naked test, from below (1), from above (2), and in side view (3). $\times 1.5$. (After Th. Mortensen, "Ingolf" Ech., ii.)

slender, curved, arranged without distinct order. The globiferous pedicellariæ (Fig. 203, 2) are rather peculiar, the valves having a large, round terminal opening with slightly serrate edge. The other pedicellariæ very simple. Colour in life probably violet. Largest size recorded, 20 mm. length.

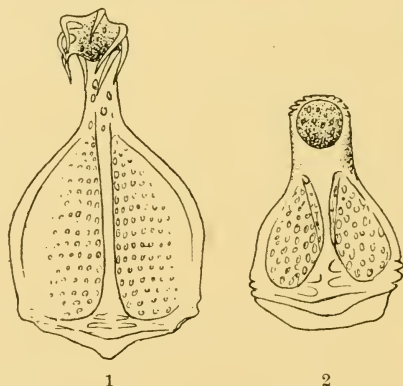


FIG. 203.—Valves of globiferous pedicellariæ of *Urechinus naresianus* (1) and *Plexechinus hirsutus* (2). 1. $\times 125$; 2. $\times 175$. (After Th. Mortensen, "Ingolf" Ech., ii.)

Biology and development unknown. From the young *Urechinus naresianus*, in which the periproct is likewise above the ambitus, this species is easily distinguished by the different outline of the test (the sternum of the latter forming no keel), by its shortened frontal ambulacrum, and the quite different globiferous pedicellariæ (Fig. 203, 1).

In British seas this species has been found only once (one specimen), at 61° 15' N., 9° 35' W., 900 m. ("Thor"). It is only known elsewhere from Denmark Strait and off S.W. Iceland, 873-2340 m. ("Ingolf").

II. Family POURTALESIIDÆ.

Mouth placed vertically at the end of a deep oral invagination. Second plate of the anterior paired interambulacra paired, the two plates of this number being placed side by side ("amphiplacous"). Pores all simple. Apical system usually disconnected. A subanal fasciole usually present. Shape of test very diversified, often very elongate, more or less bottle-shaped.

Two genera are represented in the British (and N.E. Atlantic) seas.

Key to the genera of Pourtalesiidæ of the British seas.

- Not very slender forms; posterior paired bival ambulacra disconnected (Fig. 204, 1) 1. *Pourtalesia* A. Ag.
 Very slender forms; posterior paired bival ambulacra continuous (Fig. 204, 2) 2. *Echinosigra* Mrtsn.

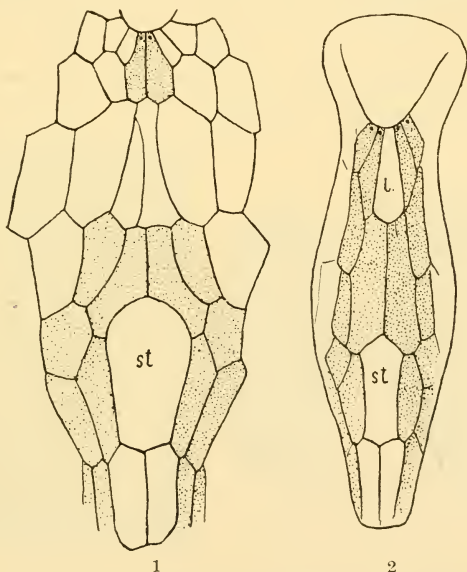


FIG. 204.—Outline figures for showing the plate arrangement of the ventral side (the bivium) in *Pourtalesia jeffreysi* (1) and *Echinosigra phiale* (2). It is seen that the plates of the bival ambulacra (punctated) are disconnected in *Pourtalesia*, while in *Echinosigra* they are contiguous. (After Lovén, On *Pourtalesia* (1), and Th. Mortensen, "Ingolf" *Ech.*, ii.)

st, Sternum; l, Labrum.

1. *Pourtalesia* A. Agass.

Shape of test more or less cylindrical, not narrowed in the anterior part. The front end vertical. Posterior interambulacrum forming a dorsal and ventral keel, the latter continuing into a rather prominent anal snout, surrounded by a fasciole. Periproct situated in a small depression above the anal snout. The posterior paired interambulacra unite on the under side of the test, thereby separating the first plates of the two posterior ambulacra from the following ones. Labrum, which is usually invisible from the outside and is more or less rudimentary, lying wholly within the oral invagination, is widely separated from the second plate of the posterior interambulacrum (the sternum), also the first ambulacral plates of the neighbouring ambulacra joining in the ventral mid-line (Fig. 204). Apical system at the frontal edge of test, disconnected.

Two species are known from the British (and N.E. Atlantic) seas.

Key to the species of Pourtalesia occurring in the British seas.

Dorsal keel overhanging periproct 1. *Pourt. Jeffreysi* Wyv. Th.
 „ „ not overhanging the periproct 2. *Pourt. Wandeli* Mrtsn.

1. *Pourtalesia Jeffreysi* Wyv. Thomson. (Fig. 205.)

Test broadest in the middle, somewhat narrowing towards

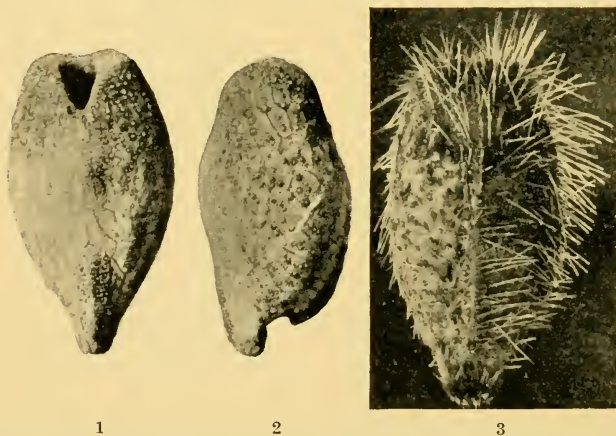


FIG. 205.—*Pourtalesia Jeffreysi*; naked test, from below (1) and in side view (2). Specimen with the spines preserved, from the dorsal side (3). Slightly reduced. (After Th. Mortensen, "*Ingolf*" Ech., ii.)

the front end. Under side rather conspicuously swollen; posterior interambulacrum forming a fairly conspicuous dorsal keel (not

always as high as is the figure), which continues as a distinct prominence over the periproct. The larger tubercles of the antero-lateral ambulacra arranged in a fairly conspicuous transverse series on each plate, the posterior tubercle in each series being the largest. The primary spines are of rather uniform length, the longest scarcely exceeding one-third the length of test. Globiferous pedicellariæ do not seem to occur. The tridentate and triphyllous pedicellariæ are not characteristic, small with simply leaf-shaped valves. The ophicephalous pedicellariæ are very elegantly shaped, the valves being slender, with deeply serrate outer edge (Fig. 206, 3). The rostrate pedicellariæ,

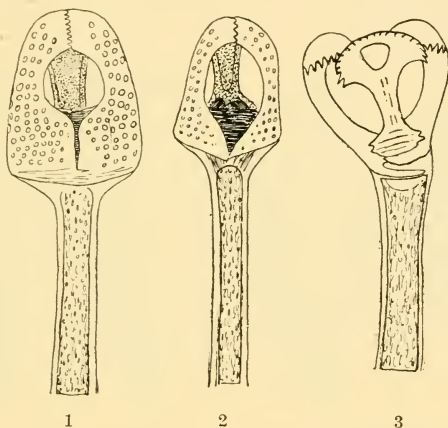


FIG. 206.—Rostrate pedicellaria of *Pourtalesia Wandeli* (1) and of *Pourt. Jeffreysi* (2); ophicephalous pedicellaria of *Pourt. Jeffreysi* (3). $\times 55$. (After Th. Mortensen, "Ingolf" *Ech.*, ii.)

which are fairly conspicuous, up to 0.5 mm. length of head, and more or less darkly pigmented, have rather slender valves (Fig. 206, 2). Colour in life purplish-violet. Reaches a size of ca. 60 mm. length.

Biology and development unknown.

In British seas this species is known only from the cold area of the Faroe Channel, where it was first discovered (half-way between Shetland and Faroe), in 1150 m. depth, by the "Porcupine." Also found there by the "Knight Errant". The species is elsewhere distributed all over the cold area of the Norwegian sea, from N. of Iceland to Spitzbergen and the Kara Sea, in depths of ca. 225-2450 m.

2. *Pourtalesia Wandeli* Mrtsn. (Fig. 207.)

(Syn. *Pourtalesia miranda* Hoyle, Kemp; probably not
Pourt. miranda A. Agassiz.)

Test nearly cylindrical, scarcely widening from in front posteriorly. Under side nearly flat, not swollen; the dorsal keel formed by the posterior interambulacrum less conspicuous and not forming a prominence above the periproct. The serial arrangement of the larger tubercles in anterior part of test rather more distinct than in the preceding species. Primary spines very long, the largest exceeding two-thirds the length of test. The pedicellariæ in the main as in the preceding species, only the rostrate pedicellariæ differ in the valves being broader and more

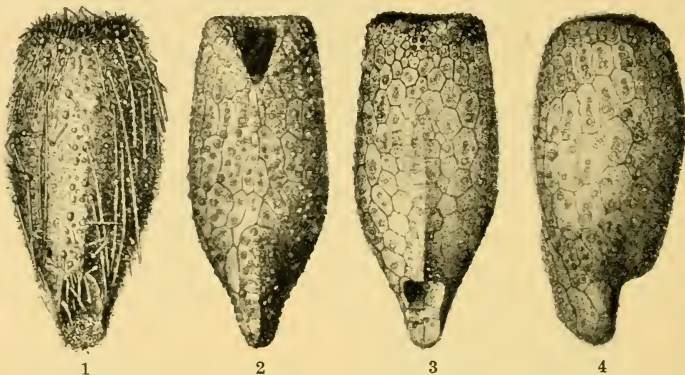


FIG. 207.—*Pourtalesia Wandeli*. 1. Specimen with the spines preserved; dorsal side. 2-4. Naked test, from below (1), from above (2), and in side view (3). Slightly reduced. (After Th. Mortensen, "*Ingolf*" *Ech.*, ii.)

densely serrate at the point (Fig. 206, 1). Colour in life dark violet. Largest size recorded, 53 mm. length.

Biology and development unknown.

From the British seas this species has only been recorded by Agassiz, under the name of *Pourtalesia miranda*, from off Rockall, 56° 44' N., 12° 52' W., 2185 m. ("Porcupine"); it would, however, seem most probable that the specimen from the "Porcupine" was really *Pourt. Wandeli*. The species is otherwise distributed over the Northern Atlantic from off the Faroes to the Davis Strait and the West Indies. Bathymetrical distribution, 1580-3230 m.¹

¹ H. L. Clark has recently declared *Pourtalesia Wandeli* identical with the West Indian *P. miranda* A. Agass., because some specimens from the West Indies identified by A. Agassiz as *Pourt. miranda* are indistinguishable

2. *Echinosigra* Mrtsn.

Test more or less conspicuously narrowed in the anterior part, again widened in the front, giving the appearance of a head and neck. A distinct dorsal and ventral keel, the latter continuing into a distinct anal snout, surrounded by a fasciole. Periproct situated above the anal snout. The posterior paired ambulacra not disconnected, the postero-lateral interambulacra not uniting on the ventral side. Labrum, which is large and distinctly seen from without, is widely separated from the second plate of the posterior interambulacrum through the neighbouring ambulacra joining in the ventral mid-line behind the labrum (Fig. 204, 2). Apical system disconnected, at the frontal edge of the test.

The two only known species of this genus probably both occur in the British seas.

Key to the species of Echinosigra.

Neck moderately long	1. <i>Ech. phiale</i> (W. Th.)
„ very long and slender	2. <i>Ech. paradoxa</i> Mrtsn.

1. *Echinosigra phiale* (Wyv. Thomson). (Fig. 208.)

(Syn. *Pourtalesia phiale* Wyv. Thomson.)

Test not very much narrowed in the anterior end, forming only a short neck; middle part of body not conspicuously swollen. Labrum and adjoining ambulacral plates only moderately long. The enlarged second plates of these ambulacra, which join in the mid-ventral line behind the labrum, with a short dividing line in the anterior edge. Anal snout not bent upwards. Periproct scarcely sunk. Spines short, scattered, mostly bifid at the point. Globiferous pedicellariæ unknown. Tridentate pedicellariæ (Fig. 209, 1) very characteristic, with the valves ending in a long point; the ophicephalous mainly as those of *Pourtalesia*, only with fewer serrations; the rostrate (Fig. 209, 3) with the blade

from *P. Wandeli*. In the opinion of the present author the original description and figures of *Pourtalesia miranda* (in *Revision of Echini*, p. 345, Pl. XVIII.) make the identity of the two forms improbable. The fact that specimens from the West Indies, later on identified by Agassiz as *P. miranda*, are identical with *P. Wandeli*, only prove that also the latter species occurs in the West Indies. The type specimen of *P. miranda* having been lost, the question of the possible identity of the two forms cannot be definitely solved at present. The West Indian specimens referred to *P. Wandeli* were taken in depths of only 435-1035 m.

more excavate than in *Pourtalesia*. Colour of preserved specimens white. Largest size recorded, 18 mm., but as the genital

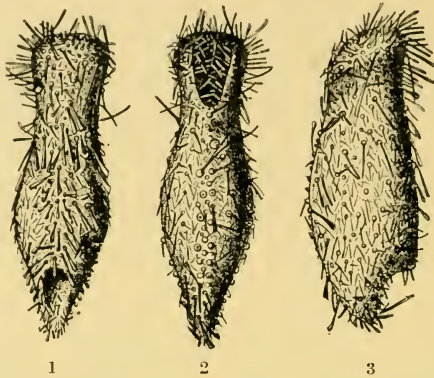


FIG. 208.—*Echinograptus phiale*. $\times 2.3$. (After Th. Mortensen, *Echinoidea Deutsche Südpolar Exped.*)

1. From above. 2. From below. 3. Side view.

openings have not yet appeared in specimens of that size, it must reach a larger size than this.

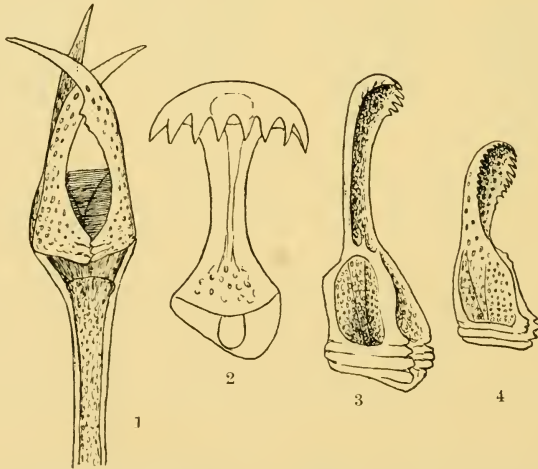


FIG. 209.—Tridentate pedicellaria (1), valves of ophicephalous (2), and of rostrate pedicellaria (3) of *Echinograptus phiale*; valve of rostrate pedicellaria of *Echinograptus paradoxa* (4). 1, $\times 85$; 2-3, $\times 145$; 4, $\times 105$. (After Th. Mortensen, *Echin. Deutsche Südpolar Exped.* (1-3), and "Ingolf" *Echin.* ii. (4).)

Biology and development unknown.

This species is known with certainty only from off S.W. Iceland ("Ingolf") and the Antarctic Sea ("Gauss"). It is

recorded also from S.W. of the Rockall Bank ("Porcupine"), but it is impossible now to decide whether the "Porcupine" specimen belonged to this or the following species, the specimen having apparently been lost. Bathymetrical distribution, 1520-3220 m.

2. *Echinosigra paradoxa* Mrtsn. (Fig. 210.)

Differs from the preceding species by its much longer and more slender neck; also the middle part of the body more swollen, the posterior part again narrowing into what might almost be termed a tail. The labrum and the adjoining ambulacral plates very long; the second plates of these ambulacra,

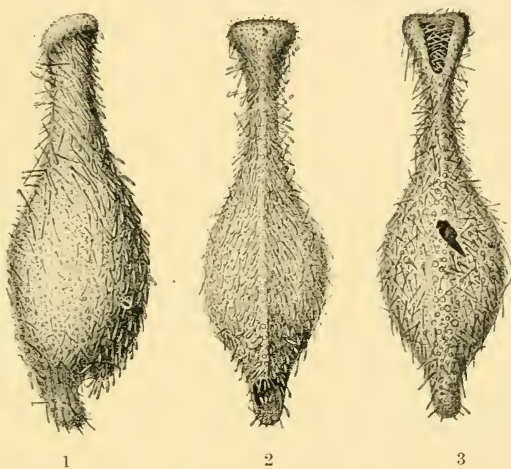


FIG. 210.—*Echinosigra paradoxa*. $\times 1.5$. (After the "Ingolf" *Echinoidea*, ii.)

1. Side view. 2. Dorsal. 3. Ventral side.

which join in the mid-ventral line behind the labrum, with a long dividing line in the anterior edge and a shorter one in the posterior edge; these lines, however, do not join, the plates being thus not really subdivided. Anal snout curved slightly upwards. Periproct slightly sunk. Only two genital openings. Spines and pedicellariæ as in the preceding species, only the rostrate with the valves slightly different, with more serrations (Fig. 209, 4). Colour in life probably white; the test fairly transparent. Largest size recorded, 37 mm. in length.

Development unknown. The remarkable shape, in fact the most extreme of all Echinoids known, must necessarily confine this species to the perfectly quiet and soft deep-sea bottom, as

it would run a great risk of breaking its neck with any movement of the water and also would evidently be unable to right itself again if it happened to turn over.

Known with certainty only from off S.W. Iceland, 1515-1640 m. ("Ingolf"); but, as stated under the preceding species, it is very probable that the "Porcupine" specimen from the Rockall was really this species.

V. Class. SEA-CUCUMBERS OR HOLOTHURIANS

(HOLOTHURIOIDEA)

Free-living echinoderms, usually with an elongated, worm- or sausage-shaped body, without free arms, but with a circle of tentacles around the mouth, which latter is usually at the anterior end of the body. The œsophagus surrounded by a calcareous ring. Alimentary canal long, mostly looped. Anus usually at the posterior end. Skeleton generally consisting of small, microscopical plates imbedded in the skin, sometimes of larger, imbricating plates, which are, however, never arranged in regular series. Tube-feet never in a furrow.

The *body* of the Holothurians is usually elongate, worm- or sausage-shaped, more rarely short, radish-shaped; it is often flattened, showing a distinct ventral and dorsal surface. To the ventral side belong always three radii, to the dorsal side two, the tube-feet being generally most strongly developed on the ventral side, which forms the walking surface. The ventral side is also called the "trivium", the dorsal side the "bivium", on account of the relative number of the radii. The *skin*, which is not ciliated, is mostly thick, leathery; in the group of the Apodous Holothurians, however, generally thin and transparent. There is no continuous *skeleton* consisting of regularly serially arranged plates, as found in all the other classes of echinoderms, but only small, mostly microscopical *calcareous bodies*, imbedded in the skin. They may be so numerous and lie so closely crowded together that the skin becomes quite stiff and hard; in one group, the Psolids, the calcareous bodies have developed into large, imbricating scales. A few forms entirely lack the calcareous bodies. Often the calcareous bodies are of a very beautiful, regular shape, wheels, anchors, etc.; they are characteristic for every species and are of eminent importance for the classification of the Holothurians. As a rule it is necessary to use a special preparation in order to see them distinctly, clearing up pieces of

skin in Canada balsam or dissolving pieces of skin by means of potash or hypochlorite of sodium ("Eau de Javelle"), and thus isolating them.

Under the epidermis comes a layer of circular muscles, interrupted by the five strong longitudinal or *radial muscles*, which run through the whole length of the body, from mouth to anus; each radial muscle may be divided into two parallel halves. *Retractor muscles* may occur; they issue from the radial muscles, at various distances from the anterior end, passing through the body cavity to the calcareous ring. They serve to retract the anterior end of the body, with the mouth and the tentacles. The retractile part of the body wall, the "*introvert*", is usually thinner than the rest of the body wall and the calcareous bodies contained in it are usually somewhat scarcer and often somewhat different in shape from those of the rest of the skin. The *tube-feet* are principally arranged in five double series, but they often become pluriseriate, especially in the ventral (trivial) radii, and they may even spread over the whole body. They may be confined to the ventral side alone, or they may be present in the shape of papillæ, without sucking disk, on the dorsal side. They always issue directly from the surface, are never placed in furrows. Tube-feet are entirely lacking in the Synaptids, and in the Molpadids they are represented only by papillæ around the anus. The *tentacles* may be bush-shaped, shield-shaped, feather-shaped or simply finger-shaped. Their number is mostly 10, 12, 15, or 20, but it may sometimes be 8, 11, 25, or even 30. Their shape is very constant in the various groups and affords a systematic character of primary importance.

The *mouth* usually is at the anterior end, but may in some forms be situated more or less ventrally, in others dorsally. It is unarmed. The œsophagus, on the other hand, is surrounded by a structure highly characteristic of the Holothurians, the *calcareous ring* (Fig. 211). This consists of usually 5 radial and 5 interradial pieces, of rather different form in the various groups and therefore of considerable importance for classification. The radials mostly differ in shape from the interradials, and usually have a notch in the anterior edge over which the radial muscle and radial nerve pass. The notch may close itself and thus form a hole through which the radial nerve passes (some Synaptids). The radials may have a posterior, bipartite prolongation, sometimes (*Pseudocucumis*) also the interradials may have a posterior prolongation. These prolongations may be articulated, as also the whole calcareous ring may be divided into a number of smaller

pieces. On the whole there is great variation in the structure of the calcareous ring. In some deep-sea forms only the five radials are developed. A single form, *Pelagothuria*, lacks the calcareous ring completely.

The *alimentary canal* is a long, usually simple tube; generally it forms a loop, passing first directly backwards along the mid-dorsal interradius, then bending abruptly and passing forwards in the left dorsal interradius towards the anterior end, where it bends again, passing into the right ventral interradius, and then straight to the posterior end, where it opens. In the Dendrochirotes, excepting the Psolids, the posterior part of the intestine, however, lies in the left ventral interradius. It is suspended in a mesentery which is attached to the body wall in the corre-

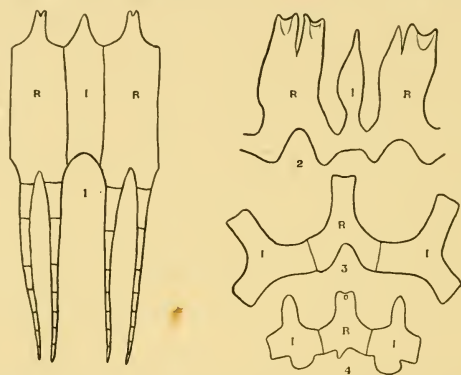


FIG. 211.—Part of the calcareous ring of various Holothurians. $\times 2.5$.
(From *Danmark's Fauna*.)

1. *Thyone fusus*. 2. *Thyonidium pellucidum*. 3. *Psolus squamatus*. 4. *Myriotrochus vitreus*. R, Radial; I, Interradial.

sponding interradii. In the Elaspipods, however, the mesentery of the posterior loop is attached in the right dorsal interradius. In forms with a straight intestinal canal the mesentery still passes from the mid-dorsal interradius in the anterior end to the right ventral interradius in the posterior end. The rectum, or *cloaca*, which plays an important rôle in respiration, is connected with the body wall by numerous muscles. On the contraction of these muscles the cloaca is widely distended, and an inward water-current produced; when the muscles are relaxed the water is pressed out again. From the cloaca issue in many Holothurians a pair of more or less strongly branching, bush-shaped, hollow organs, the *respiratory trees* (or water lungs), in which the water alternately flows in or out by the widening or contracting of the cloaca; these are the special respiratory

organs. They are entirely lacking in the Synaptids and some deep-sea forms. When most developed (the Aspidochirotēs) the left respiratory tree is spun into a net of fine blood-vessels (*rete mirabile*), which are in direct connection with the blood-vessels of the intestinal canal. On the cloacal wall are found in various Aspidochirotēs the so-called *Cuvierian organs*, a sort of protective organ, worm-shaped bodies which are pushed out through the cloacal wall; they swell in the water and become very sticky, entangling animals with which they come into contact (the "cotton-spinner" of the British seas is a good example of this). In most Synaptids there are found on the inside of the body wall, or on the mesentery, some peculiar small cup-shaped, strongly ciliated organs, the *ciliated funnels* or urns, which have probably some excretory function; they are of rather diversified shape and of no small systematic value. In *Labidoplax Buski*, and probably other Synaptids, a pair of large pores are found in the posterior end of the body; they may open and close, and probably also have some excretory function. Some Synaptids have peculiar "contractile rosettes", of a rather complicated structure, on the inside of the body wall near the calcareous ring; their function is unknown.

From the *watervascular ring* or ring canal, which surrounds the œsophagus behind the calcareous ring, the radial water-vessels issue (Fig. 212), running at first forwards on the inside of the calcareous ring, between the latter and the œsophagus, then backwards, to the posterior end of the body, lying in the body wall, covered by the longitudinal muscles. They give off canals to the tentacles; in the Synaptids, where the radial water vessels are usually absent or at least rudimentary, the tentacle canals issue from the ring canal. From the tentacle canals large *ampullæ* may issue, hanging free in the body cavity, as do the *Polian vesicles*, of which there may be one or more. The *stone canal*, which issues from the watervascular ring in the mid-dorsal line, and is usually fastened to the mesentery, usually opens into the body cavity; only in some deep-sea forms, a few Synaptids and *Pelagothuria*, it opens outwards through the skin, which is, no doubt, the more primitive arrangement. The stone canal usually ends in a small swelling, which corresponds to the madreporite of other echinoderms. Some forms have several stone canals (e.g. Fig. 212). The *axial organ* has not been found with certainty in the Holothurians. The *nerve system*, which accompanies the watervascular system, lies wholly inside the epidermis; the dorsal nervous system is not represented. *Sensory organs* are

feebly developed. Very simple light-perceiving organs may occur; in Synaptids and Elpidiids there are small statocysts at the radial canals. Small sensory cups, usually stalked bodies with a small ciliated groove at the end, occur on the tentacles, sometimes also on the body wall of Synaptids. The *genital organs* (gonads)

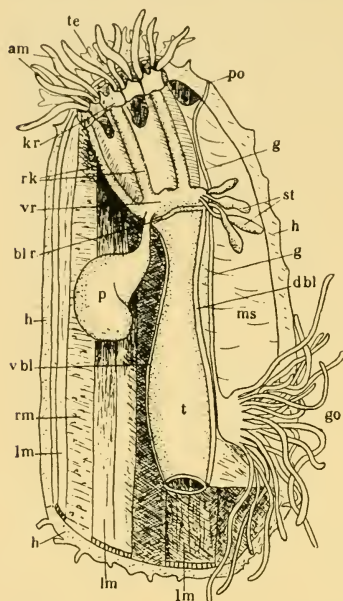


FIG. 212.—Anterior end of *Holothuria tubulosa*; the body wall of the left side removed in order to show the inner anatomy. (Modified, after Goodrich; from *Danmark's Fauna*.)

am, Tentacle ampullae, bent forwards in order to show the calcareous ring; bl r, Circular blood-vessel; d bl, Dorsal blood-vessel of intestine; g, Effluent duct of genital organs; go, Genital organs (gonads); h, The skin; kr, Calcareous ring; lm, Longitudinal muscles; ms, Mesentery; p, Polian vesicle; po, Genital pore; rk, Radial canals; rm, Circular muscles; st, Stone canals; t, Alimentary canal; te, Tentacles; v bl, Ventral blood-vessels; vr, Watervascular ring.

are found only in the mid-dorsal interradius; they consist of a number of branched or unbranched long tubes, mostly on each side of the mesentery, but in some forms only on one side. They all open through a single duct imbedded in the mesentery, on the dorsal side, mostly at the base of the tentacles, sometimes at the tip of one of the tentacles; in some deep-sea forms the genital opening is situated farther back on the dorsal side, sometimes even at the posterior end. Not rarely the genital opening lies at the tip of a small papilla. The efferent duct is sometimes divided, opening through several pores (e.g. *Cucumaria frondosa*). The Holothurians generally have separate sexes, but several of them, e.g. most Synaptids, are hermaphrodite, usually so that eggs and sperm develop in the same gonad, but at different times, the individual being thus alternately male and female. Some Holothurians are viviparous; among the North European forms this, however, is the case with only one species, *Leptosynapta minuta*. Other, mainly

Antarctic, Holothurians are brood-protecting; only a single Arctic species, *Cucumaria glacialis*, is known to protect its brood.

Several Holothurians, e.g. (probably) most of the Aspidochirotres and some Synaptids, have a pelagic larva, the so-called

Auricularia (Fig. 3, 1). It has no skeleton, only scattered calcareous spicules, usually elegantly shaped wheels. From the Asteroid larvæ, which likewise lack a skeleton, the *Auricularia* is distinguished by the preoral part of the ciliated band (the frontal area) not being separated off from the ciliated band of the dorsal side, but being in direct continuation therewith at the anterior end of the larva. No Dendrochirote is known to have an *Auricularia* larva; the species of this group appear all to have direct development, with a simple, barrel-shaped (mostly red) larva, provided with ciliated rings. On metamorphosis the *Auricularia* undergoes a remarkable change; the ciliated band partly dissolves and the remaining parts arrange themselves so as to form rings round the body, which now becomes fusiform; this stage is designated the pupa stage. Some *Auricularias* reach a fairly large size; *Auricularia nudibranchiata* Chun reaches a length of 6 mm., and a related Japanese species even 15 mm. Another fairly large form is the *Auricularia antarctica* MacBride, which is up to 4 mm. long.

The only *Auricularia* recorded from the British seas is that of *Labidoplax digitata*, which has been observed by Chadwick at Port Erin in the month of July. There can, however, be no question but that at least one more kind of these larvæ must occur there, namely, that of *Holothuria Forskali*. Possibly also *Auricularia nudibranchiata* may occur there; this larva, which was originally found at the Canaries, has been found at the Azores, and even as far north as 45° 32' N., 25° 50' W. It would therefore not seem unreasonable to expect it to occur also near the Irish west coast. It is not known to which Holothurian this larva belongs; probably it belongs to some deep-sea Holothurian.

*Key to the Auricularias known from or likely to occur
in British seas.*

1. No wheels present, only a star-shaped spicule in the posterior end; the body very simple, H-shaped, the vibratile band running nearly straight forwards and backwards

Holothuria Forskali

Wheels present, no star-shaped spicules; vibratile band forms a number of simple or folded lobes 2

2. Lobes of ciliated band simple (Fig. 3, 1); wheels present only in postero-lateral lobes *Labidoplax digitata*

Lobes of ciliated band very strongly folded; wheels scattered irregularly all over the body *Auricularia nudibranchiata*

The Holothurians are very sluggish animals, which live buried

in the ground, or attached to stones, etc., or creep over the bottom, mainly by means of the contractions of the body musculature. Especially in the transparent Synaptids the peristaltic movements of the body wall are seen very beautifully, like waves proceeding gently from one end of the body to the other. The tube-feet are not very important as organs of movement; they serve rather for attachment. In Synaptids the calcareous corpuscles are of importance as organs of movement. Some forms (*Bathyplores natans* and, probably, several deep-sea forms, e.g. *Psychropotes*) can swim, with bending, up-and-down movements. A few are wholly pelagic (*Pelagothuria*, *Planktothuria*). Some Holothurians (*Pseudostichopus*, *Meseres*) cover their skin with foreign bodies, sand, shells, sponge spicules. The sea-cucumbers of the British seas are, with a few exceptions (e.g. *Cucumaria frondosa*, *Holothuria Forskali*), small forms; in tropical seas several good-sized forms occur, about a metre long, e.g. some Synaptids which live in quite shallow water, on coral reef flats or creeping among the sea-grass. The food of the sea-cucumbers consists of bottom material, which is shovelled into the mouth by means of the tentacles (Aspidochirotas, Molpadids, Synaptids), or of plankton and detritus, which is caught by the tentacles (Dendrochirotas); they lie with their tentacles widely extended and then alternately bend them down and put them into the mouth, thus sucking off the organisms or detritus particles which stick to the tentacles.

As in other echinoderms the power of *regeneration* is very great. Most Holothurians, especially the larger forms, usually contract very strongly under unfavourable circumstances and may then expel all their inner organs through the anus or through a rupture in the skin. Such eviscerated specimens are able to regenerate again all their organs in the course of some time; in *Stichopus tremulus* it takes 2-3 weeks, in a tropical form it has been observed that the regeneration is completed in 9 days. The anterior end, with tentacles and calcareous ring, may also regenerate, at least in some Dendrochirotas. In the Synaptids, which, under unfavourable circumstances, are apt to constrict their body in various places, and break to pieces, the anterior end will regenerate the rest of the body, while the other parts are not able to do so. Propagation by means of autotomy occurs normally in a few forms, e.g. *Cucumaria lactea* and *Psolus valvatus*. Budding (a new anterior end forming on the side of the body, beneath the original anterior end) has been observed in *Cucumaria lactea*. In a small tropical sea-cucumber (*Thyone gibbera* Sel.)

coalescence has been observed in specimens lying so close together as to be in contact with each other.

Parasites occur in no small numbers in the Holothurians. Various Protozoa, Planarians, Nematodes, and Copepods may occur in their body cavity or intestinal canal. Some crabs (*Pinnotheres*) live in the cloaca or respiratory trees; another crab, *Lissocarcinus orbicularis* Dana, lives between the tentacles of various tropical Holothurians. An Actinian, *Sicyopus commensalis* Gravier, lives on the deep-sea Holothurians *Pseudostichopus villosus* and *Paroriza Prouhoi* Hér. A Tardigrade, *Tetrakentron synaptæ* Cuénot, lives on the tentacles of *Leptosynapta inhærens*; the Rotifer *Discopus synaptæ* Zel. lives on the skin of Synaptids. Some species of Polynoid worms live on the skin of various sea-cucumbers, likewise some molluscs (*Eulima*). Some very strongly modified Gastropods are found parasitic in Holothurians: *Entoconcha mirabilis* Joh. Müll. in *Labidoplax digitata*, *Enteroxenos Oestergreni* Bonnevie in *Stichopus tremulus*, *Entocolax Ludwigi* Voigt in *Myriotrochus Rinkii* (and a related form in *Myriotrochus Thééli*, according to Hj. Östergren); they are long, worm-shaped bodies, very unlike normal Gastropods, but their young are typical larval snails, provided with a normal shell. They are found attached to the œsophagus or intestine (*Entocolax* to the body wall), hanging from there free into the body cavity of the Holothurian; they may also occur free in the body cavity. Also a considerably modified mussel, *Entovalva mirabilis* Voeltzkow, is found parasitic in the œsophagus of a tropical Synaptid. A small fish, *Fierasfer*, lives in the cloaca and respiratory trees of various larger Aspidochirotés.

The sea-cucumbers are not much eaten by fishes; still *Thyonidium pellucidum* and *Psolus phantapus* are of some importance as food for the cod. It appears that fishes often bite off the tentacles of Dendrochirotés. Sea-stars often devour sea-cucumbers, e.g. *Psolus*. As food for man the sea-cucumbers play an important rôle in the Indo-Pacific regions; various of the larger Aspidochirotés living in shallow water are dried and smoked and, under the name of "Trepang" or "Bêche de Mer", form an important article of commerce; they are especially a favourite dish with the Chinese.

On account of the slightly developed skeleton the Holothurians are very little fit for being preserved as fossils, and therefore are of very little importance in palæontology. Only some anchors and wheels of Synaptids are known with certainty in a fossil state. The interpretation of some imprints

from Lower Cambrian (N. America) as Holothurians is, at least, disputable.

The preservation of Holothurians generally offers some difficulties, because they—especially the Dendrochirotes—retract their tentacles or by the strong muscular contraction expel their intestinal organs. Generally they are rather easily narcotised by adding sulphate of magnesium to the sea-water, and thus they may be preserved with the tentacles expanded. They should always be preserved in alcohol, not in formaline, in which the calcareous bodies are mostly dissolved, identification thereby being made uncertain. Preservation in formaline-alcohol (the formaline neutralised) is often recommendable, but the specimens should then be transferred to alcohol.

The presence or absence of tube-feet and respiratory trees, and the shape of the tentacles, are mainly used as a foundation for classification. The issue of the tentacle canals from the radial canals or from the watervascular ring has also been made the foundation for a primary subdivision, but it appears from more recent researches that this character is not of such fundamental importance as it was formerly supposed to be. The more natural classification appears to be the one dividing the Holothurians into the five orders: Elasipods, Aspidochirotes, Molpadonians, Dendrochirotes, and Apodous Holothurians,¹ all of which are, or (the Molpadonians) will probably be found to be, represented in the British seas.

Key to the orders of the Holothurioidea.

1. Tube-feet well developed; tentacles shield- or bush-shaped 2
 Tube-feet either completely lacking or present only in the shape
 of small papillæ round the anal opening. Tentacles feather-
 shaped or digitate 4
2. Tentacles shield-shaped; no retractor muscles 3
 ,, bush-shaped; retractor muscles present

III. *Dendrochirota*

3. Respiratory trees absent; mesentery of the posterior loop of the intestine attached in the right dorsal interradius

I. *Elasipoda*

Respiratory trees present; mesentery of the posterior loop of the intestine attached in the right ventral interradius

II. *Aspidochirota*

¹ The classification here adopted differs to some degree—especially in the position of the Synallactids—from that given in the author's work on the echinoderms in *Danmark's Fauna*; the rearrangement is due to the important arguments produced quite recently by Sven Ekman ("Systematisch-phylogenetische Studien über Elasipoden u. Aspidochiroten", *Zool. Jahrb., Abt. f. Anat. u. Ontogenie*, 47, 1925).

4. Anal papillæ, tentacle ampullæ,¹ and respiratory trees present ;
 body thick, sausage-shaped, ending in a thin caudal pro-
 longation IV. *Molpadonia*
 Anal papillæ, tentacle ampullæ, and respiratory trees absent.
 Body worm-shaped, without a caudal prolongation V. *Apoda*

I. Order. ELASIPODA Théel.

Tube-feet usually present ; tentacles shield-shaped (in *Pelago-
 thuria* more dendritic) ; retractor muscles and respiratory trees
 absent. Mesentery of the posterior intestinal loop attached in
 the right dorsal interradius, usually near the right dorsal longi-
 tudinal muscle. Among the calcareous bodies are pointed rods
 and such as are derived from pointed rods. Shape of body
 usually bilateral-symmetrical.

All Elaspods are deep-sea forms, living on mud bottom.
 They fill their intestinal canal with mud, subsisting thus on the
 organic substances contained in the mud. Some of them, like
Psychropotes and *Scotoanassa*, are probably active swimmers in
 the deeper layers of the sea. Development entirely unknown.

To this order, which otherwise comprises only deep-sea forms,
 the pelagic form *Pelagothuria* also is usually referred, as an
 aberrant Elaspod. The order is divided into five families, of
 which only one, the *Lætmogonidæ*, is known to be represented in
 the British seas. There can, however, hardly be any doubt
 that they will all prove to be represented there.

*Key to the families of the Elaspoda known from or likely to be
 represented in the British seas.*

1. Body ovoid, without tube-feet, but with a circular disk round
 the anterior end, supported by long rays. Calcareous bodies
 absent *Pelagothuriidæ*
 Body bilaterally symmetrical ; tube-feet well developed ; no
 circular disk round the anterior end. Calcareous deposits
 present 2
2. Lateral papillæ present, non-retractile ; the calcareous deposits
 of the papillæ arranged parallel to the longitudinal axis of the
 latter. Skin usually thin, parchment-like or brittle
Deimatidæ
 No non-retractile lateral papillæ, but more or less well developed
 lateral tube-feet ; calcareous deposits of the papillæ not
 arranged parallel to the longitudinal axis of the latter. Skin
 usually thick, gelatinous 3

¹ Tentacle ampullæ appear to be lacking in the small Arctic Molpadid,
Eupyrgus scaber Ltk.

3. A marginal fringe of appendages around the ventral surface of the body. Tentacles large, with broad disk. A tail-like prolongation of the body may be present *Psychropotidæ*
 No marginal fringe; no tail-like prolongation. Tentacles with small disk, often with finger-like lobes in the margin, or nearly pedicel-shaped 4
 4. Calcareous bodies mainly wheels I. *Lætmogonidæ*
 Calcareous bodies pointed rods or derivatives from such, or four-armed bodies with 1-4 outer projections from base of arms; wheels rarely present and then scarce *Elpidiidæ*

I. Family LÆTMOGONIDÆ

Body usually rather long, more or less cylindrical. Skin more or less gelatinous, transparent. Dorsal papillæ present all along the radii, flexible, their calcareous corpuscles not longitudinally directed spicules. Tube-feet of latero-ventral ambulacra well developed and numerous, mostly lacking in the mid-ventral ambulacrum. Calcareous bodies wheels, which occur in great numbers, and other small bodies. Calcareous ring composed of an imperfect network, not distinctly separated into radials and interradials. Gonads branched. Mesentery in the shape of a continuous membrane, present also along the second intestinal loop.

Two genera of this family are represented in the British seas, but one more, namely *Pannychia* Théel, may be expected to be represented there also, the species *P. glutinosa* Hérouard having been found off the Azores, 2102 m. ("Princesse Alice"; only one specimen known).¹ Possibly also the genus *Lætmophasma* Ludwig will be found there, a specimen too badly preserved for identifying with certainty, but probably belonging to this genus, having been found off the Azores, 1385 m. ("Princesse Alice").

Key to the genera of Lætmogonidæ known from or likely to occur in the British seas.

1. Mid-ventral ambulacrum naked; dorsal papillæ in a single or double series along each ambulacrum 2
 Mid-ventral ambulacrum with a double row of tube-feet or small papillæ; dorsal papillæ crowded 3
2. Papillæ of dorsal ambulacra long, not retractile
 I. *Lætmogone* Théel
 Papillæ of dorsal ambulacra small, retractile
 II. *Benthogone* Koehler

¹ Miss Deichmann has informed the author that in her opinion *Pannychia glutinosa* Hér. is only a young *Benthodytes lingua* Perr.

3. Mid-ventral ambulacrum with a double series of well-developed tube-feet *Pannychia* Théel
 Mid-ventral ambulacrum with numerous very small retractile papillæ, which cover the whole ventral surface
Lætmophasma Ludw.

1. *Lætmogone* Théel.

(Syn. *Cryodora* Théel.)

Mouth anterior, subventral; tentacles 15, non-retractile. Ventro-lateral ambulacra with a single row of large tube-feet, mid-ventral ambulacrum naked. Dorsal ambulacra each with a single row of very elongate, flexible, non-retractile papillæ. The skin contains numerous wheels and, besides, simple rods or cruciform bodies.

One species, *L. violacea* Théel, is known from the British seas; another species, *L. Wyville-Thomsoni* Théel, has been found in the Bay of Biscay, off the Azores and Canaries, in depths of 650-1615 m. ("Caudan", "Princesse Alice", "Michael Sars"), and may thus be expected to occur also in the British seas; it is further known from the Antarctic and the Indo-Pacific, and therefore has a cosmopolitan distribution. Bathymetrical distribution ca. 630-3300 m.

Key to the species of Lætmogone known from or likely to occur in the British seas.

Dorsal papillæ usually more numerous than lateral tube-feet; thorny cruciform calcareous bodies in the skin

1. *L. violacea* Théel

Dorsal papillæ less numerous than lateral tube-feet: no thorny cruciform bodies in the skin *L. Wyville-Thomsoni* Théel

1. *Lætmogone violacea* Théel. (Fig. 213.)

(Syn. *Lætmogone spongiosa* Théel; *L. Jourdainii* Petit;
L. Brogniarti Perrier.)

Lateral tube-feet large, 11-15 (16) in number; dorsal papillæ slender, usually more numerous than the lateral tube-feet, ca. 15-25. A short genital process in the dorsal mid-line, a little behind the tentacles. Four sorts of calcareous deposits in the skin (Fig. 214): wheels, simple spicules and thorny cruciform bodies. The wheels are of two sorts, larger, 0.12-0.24 mm. in diameter (the largest samples in the dorsal papillæ), and smaller, 0.05-0.1 mm. in diameter; the smaller wheels usually have more spokes than the larger ones. The cruciform bodies are found only

in the skin, not in the appendages. No terminal disk in the tube-feet. Colour in life violet; the colour sometimes keeps fairly well on preservation. Grows to a length of ca. 17 cm.

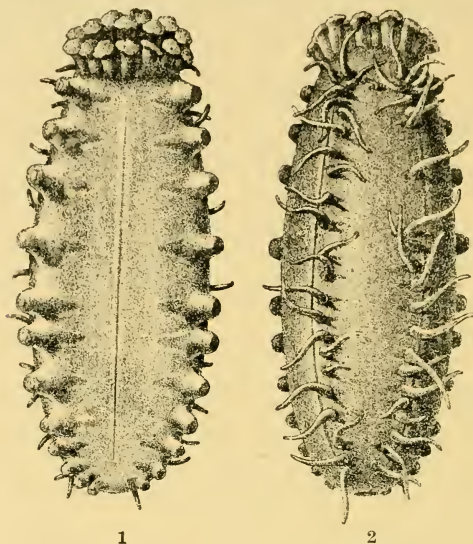


FIG. 213.—*Lætmogone violacea*; ventral (1) and dorsal side (2). Slightly reduced. (After Théel, "*Challenger*" *Holoth.*, i.)

In British seas this species is abundant, especially in depths of ca. 900 m. off the west coasts and in the warm area of the

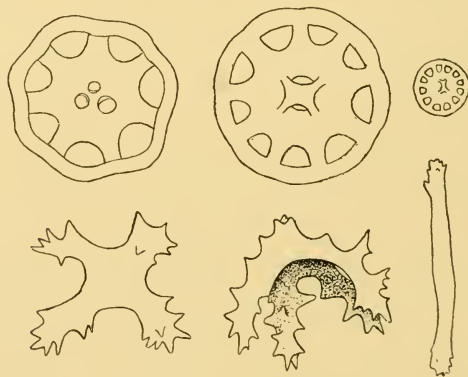


FIG. 214.—Deposits of *Lætmogone violacea*. $\times 275$. (After Perrier, "*Talisman*" *Holoth.*)

Faroe Channel. (Very probably the species *L. Wyville-Thomsoni* occurs together with it, the two species being not distinguishable

with full certainty without a microscopical examination of their calcareous deposits.) *L. violacea* is of world-wide distribution, being known from the Davis Strait to the Azores and the African coast, and from the Indian Ocean to Australia and Japan. Bathymetrical distribution ca. 225-1800 m.

2. *Benthogone* Koehler.

Mouth ventral; tentacles 15-20, retractile. Ventro-lateral ambulacra with a single row of retractile tube-feet, mid-ventral ambulacrum naked. Dorsal ambulacra each with a single or double row of small, retractile papillæ. Calcareous deposits wheels and simple rods.

Only one species known from the British (and N.E. Atlantic) seas.

1. *Benthogone rosea* Koehler. (Fig. 215.)

Body flattened or more or less cylindrical. The tentacles, which vary in number from 15-20 (mostly 18), are surrounded by a circular area limited by a circle of small papillæ. Tube-feet

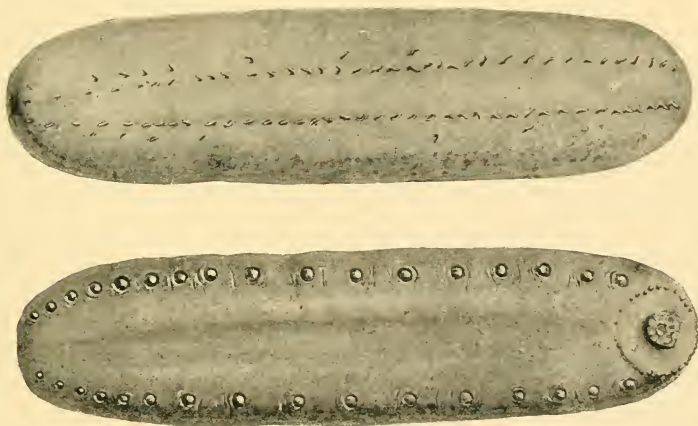


FIG. 215.—*Benthogone rosea*; dorsal and ventral side. Reduced.
(After Perrier, "Talisman" *Holothurioidea*.)

and dorsal papillæ not very close set, the latter in an indistinct double series. Wheels (Fig. 216) of one sort only, 0.06-0.16 mm. in diameter. The tube-feet and papillæ contain simple, more or less thorny rods, besides the wheels; no terminal disk in the tube-feet. Small nodules apparently only in the skin of the

ventral side. Colour in life rosy or light violet, the ventral side somewhat darker. Grows to a length of ca. 22 cm.

The varieties *cylindrica* and *4-lineata* of Perrier are only founded in various stages of contraction due to preservation and thus cannot be upheld.

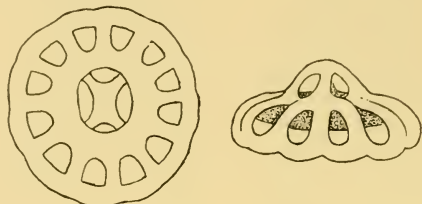


FIG. 216.—Wheels of *Benthogone rosea*, from above and in side view. $\times 200$.
(After Perrier, "*Talisman*" *Holoth.*)

In British seas this species has been found in considerable numbers off the S W. coast of Ireland, in depths of ca. 1200-1765 m. ("Helga"). It is elsewhere known from the Bay of Biscay, the Azores, and off the African coast, down to the Cape Verdes. Bathymetrical distribution ca. 1000-2320 m.¹

[Family ELPIDIIDÆ]

Body usually short, oval, sometimes almost globular. Tentacles usually 10 (thus in all the Atlantic forms). Dorsal papillæ few, not equally distributed along the radii, their calcareous deposits not longitudinally directed. Few, but fairly large tube-feet in the latero-ventral ambulacra, the mid-ventral ambulacrum naked. Calcareous deposits pointed rods or cruciform bodies; more rarely wheels occur, but always scarce in numbers. Calcareous ring composed only of the five radials, which are star-shaped, not coalesced. Statocysts are present. Gonads one or more bundles of small caecal sacs. Mesentery consisting only of isolated threads, entirely lacking along the second intestinal loop; a caecum may be present on the rectum.²

¹ The statement of its occurrence at a depth of only 16 m. (Cape Verde, "Princesse Alice") evidently rests on erroneous labelling.

² This caecum, which occurs only in the subfamily Elpidiinae, has generally been regarded as a rudimentary respiratory tree. According to the recent researches of Ekman it would appear, however, that such interpretation is erroneous. The cloaca of Elpidiids evidently has no respiratory function, neither can the caecum therefore have such a function. Also the ventral position of this caecum is against the homology with the mostly dorsally placed respiratory trees of other Holothurians.

The family contains a considerable number of genera, which are placed in two subfamilies, *Elpidiinae* and *Peniagoninae*.

Key to the subfamilies and genera of Elpidiidae represented in the N.E. Atlantic.

1. Calcareous deposits mainly pointed rods or 3-radiate bodies ; no true cruciform bodies. Rectum with a caecum. Subfam. *Elpidiinae* 2
- Calcareous deposits mainly cruciform bodies (Fig. 217, 1, 2, 7) ; rectum without a caecum. Subfam. *Peniagoninae* 6

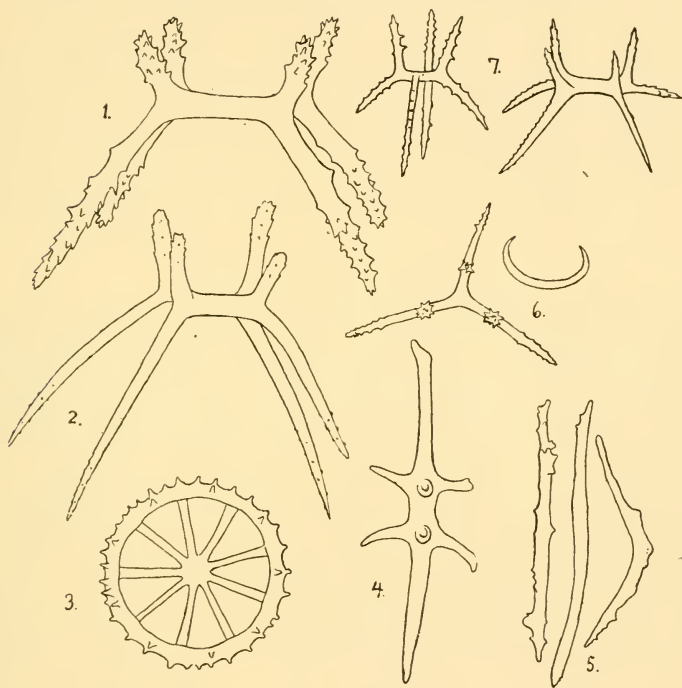


FIG. 217.—Spicules of *Peniagone porcellus* (1), *Scotoanassa translucida* (2), *Elpidia glacialis* (3, 4), *Kolga hyalina* (5), *Periamma rosea* (6), and *Peniagone ferruginea* (7). 1, $\times 100$; 5, $\times 100$; 6, $\times 133$. No exact statement of magnification with the originals of the rest of these figures. (After Perrier, "*Talisman*" *Holoth.* (1 and 6) ; Hérouard, "*Monaco*", xxi. (2) ; Théel, *Elpidia* (3 and 4) ; Ekman, *Syst. phylog. Stud. Elasp. und Aspidoch.* (5) ; Grieg, "*Michael Sars*" *Éch.* (7).)

2. Calcareous deposits mainly or exclusively pointed rods 3
- Calcareous deposits 3-radiate and C-shaped bodies (Fig. 217, 6) ; dorsal papillæ only at the anterior end of the body, may be united by a web *Periamma* Hér.
3. Calcareous rods usually with a pair of long processes in the middle (Fig. 217, 4) ; wheels (Fig. 217, 3) present in small numbers ;

- 3 anterior, 1 posterior pair of dorsal papillæ, not united by a web *Elpidia* Théel
 Calcareous rods simple (Fig. 217, 5), without long median processes 4
 4. C-shaped bodies present *Ellipinion* Hér.
 „ „ absent 5
 5. Three pairs of dorsal papillæ at anterior end of body, united or not by a web ; 7-9 tube-feet on each side of body
 Kolga Dan. and Kor.
 Five pairs of dorsal papillæ at anterior end of body, not united by a web ; 12 tube-feet on each side of body
 Irpa Dan. and Kor.
 6. Dorsal papillæ united by a web, at least at their base, forming a fan-like prominence above the anterior end of the body ; lateral tube-feet large, not united by a web . *Peniagone* Théel
 Dorsal papillæ forming an anterior prolongation of the body, not raised above the usually flat dorsal surface ; lateral tube-feet confined to the posterior end of body, united so as to form a fringe round the posterior end . . . *Scotoanassa* Théel

***Elpidia* Théel. (Fig. 218, 1.)**

Body ovoid ; the skin fairly stiff from the numerous calcareous deposits. Mouth ventral, 10 tentacles. Tube-feet of lateral ambulacra few, equally distributed along the whole edge of body. Dorsal papillæ 3 anterior and 1 posterior pairs, not united

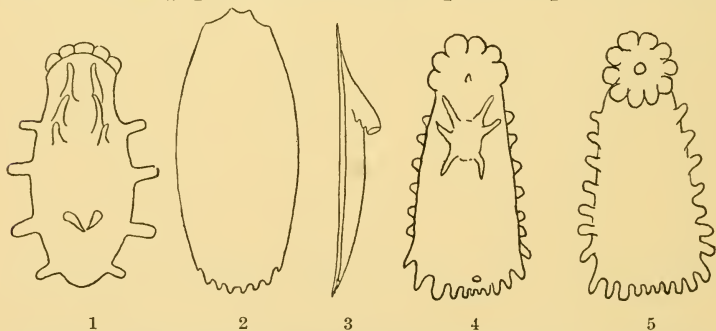


FIG. 218.—Outline figures of *Elpidia glacialis*, dorsal side (1) ; *Scotoanassa translucida*, dorsal side (2) and in side view (3) ; *Ellipinion Delagei*, dorsal (4) and ventral side (5). The two first about half size, the last natural size. (After Théel, *Elpidia*, and Hérouard, "Monaco", xxi.)

by a web. Wheels present, but few in numbers. The calcareous rods pointed, usually with some long median processes (Fig. 217, 4).

Only one species known with certainty of the genus as thus restricted, namely *Elpidia glacialis* Théel (Fig. 218, 1), which was

the first Elaspod discovered. It is an Arctic species, distributed all over the cold Norwegian sea, from N. of Iceland to the Kara Sea. It is known to go as far south as $62^{\circ} 10' \text{ N.}$, $0^{\circ} 8' \text{ E.}$, and may well be expected to go as far south in the cold area as to come into the British area (Faroe Channel). Bathymetrical distribution ca. 70-2800 m.

The species has also been recorded from off the Moroccan coasts (2210-2300 m., "Talisman"). It is, however, very improbable that this eminently Arctic form should occur so far south (and accordingly also all over the warm area of the North Atlantic). Most probably this Moroccan form will turn out to represent another species, which must then be named *Elpidia echinata* (R. Perrier), having originally been announced by Perrier under the name *Tutela echinata*. Nothing is known of its characters excepting what may be concluded from the fact that Perrier later on identified it with *Elpidia glacialis*.

Kolga Danielssen and Koren.

Body ovoid. Mouth anterior or subventral; 10 tentacles. Tube-feet of lateral ambulacra distributed along the whole edge of body. Three pairs of dorsal papillæ at anterior end of body, united or not by a web. Calcareous bodies simple, pointed rods; no wheels or C-shaped bodies.

One species, *K. hyalina* Dan. and Kor., known from the cold Norwegian sea, ca. 2030-2140 m.; another, *K. nana* Théel, from off the N. American coast, 2285 m. (also recorded from the Antarctic Sea, "Challenger"). There is some probability of these two species also occurring in the British seas, the former in the cold area of the Faroe Channel, the latter in the warm area, off the west coast of Ireland. The two species are thus distinguished:

Dorsal papillæ united by a web; mouth subventral

K. hyalina Dan. and Kor.

Dorsal papillæ not united by a web; mouth anterior

K. nana Théel

Irpa Danielssen and Koren.

Differs from *Kolga* by its elongate body and the larger number of lateral tube-feet and dorsal papillæ.

Only one species (and one single specimen) known, *I. abyssicola* Dan. and Kor., from $63^{\circ} 17' \text{ N.}$, $1^{\circ} 27' \text{ W.}$, 1977 m. It may well be expected that it will also be found farther south in the cold area, thus within the British area.

Ellipinion Hérouard. (Fig. 218, 4-5.)

Body ovoid, narrowing anteriorly. Mouth subterminal; 10 tentacles. Lateral tube-feet all along the body. Dorsal papillæ only in anterior end, often asymmetrical. Calcareous deposits simple, pointed rods and C-shaped spicules.

Only one species, *E. Delagei* (Hérouard) (Syn. *Scotoplanes Delagei* Hér.), known from the N.E. Atlantic, namely from off the Azores and Cape Verde, 1165-2478 m. ("Princesse Alice").

Periamma R. Perrier.

Body oval or elongate. 10 tentacles. Dorsal papillæ in anterior part of body forming a transverse series of 3-4 separate or coalesced papillæ, and behind these a number of very small, isolated papillæ. Lateral tube-feet usually only in the posterior half of the body. Calcareous deposits 3-radiate and C-shaped spicules; wheels may be present.

Two species are known from the N.E. Atlantic, viz. *P. furcata* (Hér.) (Syn. *Kolga furcata* Hérouard), from off the Azores and the Bay of Biscay, 1846-2320 m. ("Princesse Alice"), and *P. rosea* R. Perrier, from between the Azores and Spain, 4060-5005 m. ("Talisman"). They are thus distinguished:

The two anterior pairs of dorsal papillæ of equal length, scarcely reaching the anterior end of the body. They are united by a web nearly to their end. Three-radiate deposits with arms ca. 0.3 mm. long, each carrying a bifurcating outer process ("Monaco", xxi., p. 40) *P. furcata* (Hér.)
 The first pair of dorsal papillæ much longer than the second, distinctly surpassing the anterior end of body; the uniting web scarcely reaching beyond half their length. Three-radiate deposits with arms ca. 0.09-0.17 mm., each carrying an undivided, spinous outer process ("Talisman" *Holoth.*, p. 419)

P. rosea Perr.

Scotoanassa Théel. (Fig. 218, 2-3.)

Body more or less flattened; mouth ventral; 10 tentacles. Lateral tube-feet confined to the posterior edge of the body, united so as to form a fringe. Dorsal papillæ forming an anterior fringe, not raised above the dorsal surface. Calcareous deposits 4-armed bodies with 4 outward directed processes.

Only one species known from the N.E. Atlantic, *Scotoanassa translucida* Hérouard (Fig. 218, 4-5), found off the Azores and in the Bay of Biscay, ca. 4200-ca. 5000 m. ("Princesse Alice"). It appears that the younger stages are bathypelagic, actively swimming.

Peniagone Théel. (Fig. 219.)

Body more or less elongate, the anterior end often more or less neck-like prolonged. Tentacles 10; lateral tube-feet not united by a web, except sometimes a few at the posterior end. Dorsal papillæ only at anterior end of body, forming a raised fan-like prominence, a "veil". Calcareous deposits mainly 4-armed bodies with (1 to) 4 outwardly directed processes (Fig. 217, 7).

Seven species of this genus are known from the N.E. Atlantic, viz. *P. azorica* v. Marenzeller, from the Bay of Biscay and off the Azores, 2870-4020 m. ("Hirondelle", "Princesse Alice", "Michael Sars"); *P. ferruginea* Grieg, known only from 28° 54' N., 24° 14' W., 2800 - 3000 m. (only one specimen, "Michael Sars"); *P. foliacea* (Hérourard) (Syn. *Kolga foliacea* Hér.), from 37° 16' N., 22° 32' W., 4275 m. (only one specimen, "Princesse Alice"); *P. obsoleta* (Hérourard) (Syn. *Kolga obsoleta* Hér.), from off the Azores, 4360 m. ("Princesse Alice"); *P. porcellus* R. Perrier, from 42° 19' N., 25° 36' W., 4060 m. ("Talisman"); *P. vexillum* R. Perrier, together with the preceding species; only one specimen known; *P. Wyvillii* Théel, from 34° 59' N., 33° 1' W., 4438 m. ("Challenger"). Besides these species one more was taken by the "Ingolf", S.W. of Iceland, 2043 m., which will be described by Miss E. Deichmann under the name of *Peniagone islandica*. These 8 species are thus distinguished:



FIG. 219. — *Peniagone Wyvillii*; side view. Somewhat reduced. (After Grieg, "Michael Sars" Echinod.)

*Key to the N.E. Atlantic species of Peniagone.*¹

1. Deposits of body wall of two kinds: dorsally of the usual type, with 4 inwardly bent arms and 4 slender outer projections, all perfectly smooth; ventrally, simple cross-shaped, robust and very spinous rods. Dorsal veil large ("Talisman" *Holothuriodea*, p. 429, Pl. XIII. 6, XIX. 24-35)

P. vexillum Perr.

Deposits of body wall all of the typical form (simple cross-shaped rods may be found among the typical in the deeper layer of the skin) 2

¹ This key has been worked out by Miss E. Deichmann, to whom the author is greatly indebted for permitting its use here.

2. Short, nearly ovoid forms ; lateral appendages throughout nearly the whole length of the body 3
More or less elongate forms ; lateral tube-feet not reaching the anterior end 6
3. Veil very small, only a basal web uniting the four anterior, small papillæ ; a third, smaller pair placed behind the veil. Nine lateral tube-feet on each side. Deposits large, robust, with relatively short, very thorny outer projections (" *Talisman* " *Holoth.*, p. 426, Pls. XIII. 7-9, XIX. 15-23) *P. porcellus* Perr.
Veil well developed or very large 4
4. Veil not forming a large anterior hump or overhanging brim ; the two pairs of papillæ united by a web leaving only the tips free ; a single papilla at each side at base of veil. Five pairs of large tube-feet on each side, arranged in groups of 2 anterior and 3 posterior. Deposits small and delicate, with few spines, arms but slightly bent (" *Monaco* ", xxi., p. 41, Pls. VI. 11-15, VIII. 16, 18) *P. obsoleta* (Hér.)
Veil forming a large anterior hump or overhanging brim 5
5. Veil deeply cleft in four parts ; 2 pairs of small papillæ at base of veil. Six large tube-feet on each side and 2-3 very small ones at posterior end. Deposits of the usual type, large and strongly spinous (" *Challenger* " *Holoth.*, i., p. 42, Pl. X. 3-4 ; " *Mich. Sars* " *Echinod.*, p. 6, Pl. III. 3-5) *P. Wyvillii* Théel
Veil not cleft, forming a large anterior brim, which continues backwards along edge of body ; apparently no small papillæ at base of veil. Seven tube-feet on each side, the two posterior small. Deposits with nearly straight and smooth arms ; outer projections longer than arms (" *Monaco* ", lxvi., p. 86, Pls. I. 31, IX. 1-2) *P. foliacea* (Hér.)
6. Veil cleft to the base in the middle, thus formed by two lateral halves. Nine tube-feet of nearly equal size on each side, in the posterior two-thirds of body ; three small appendages on posterior end, united by a web. Deposits ventrally with much shorter outer projections than dorsally, finely spinous (" *Monaco* ", vi., p. 12, Pls. I. 4, II. 5) *P. azorica* v. Marenz.
Veil divided into four parts or undivided 7
7. Veil deeply incised, divided into 4 parts ; 2 pairs of small papillæ at base of veil. Five large tube-feet on each side of body in the posterior half, and 2-3 very small at posterior end. Deposits with outer projections slightly shorter than arms, spiny (" *Mich. Sars* " *Echinod.*, p. 7, Pl. I. 4-6)
P. ferruginea Grieg
Veil not divided, only with serrate margin ; one pair of small papillæ at the base of the web. Five large tube-feet on each side, and two pairs much smaller at posterior end. Deposits with outer projections as long as the arms, which are very finely spinous or nearly smooth (" *Ingolf* " *Holoth.*)

P. islandica Deichm.

[Family DEIMATIDÆ]

Body oval or elongate. Skin usually thin, parchment-like or brittle. Mouth terminal or ventral, tentacles (14) 15-20. Papillæ both along the dorsal radii and along the sides of the body; they are more or less stiff, their calcareous bodies being longitudinally directed. Tube-feet usually only in the ventro-lateral ambulacra in a single or double series. Calcareous deposits mainly cruciform bodies or large fenestrated plates; no wheels. Calcareous ring formed by a fragile, imperfect net-work, not separated into distinct radial and interradiial pieces. Gonads simple tubes. Mesentery a continuous membrane, but lacking on the second intestinal loop.

Two genera represented in the N.E. Atlantic.

Key to the N.E. Atlantic genera of Deimatidæ.

Tentacles small, retractile. Tube-feet of ventro-lateral ambulacra in a single row *Deima* Théel
 Tentacles large, non-retractile. Tube-feet of ventro-lateral ambulacra in a double row *Oneirophanta* Théel

Deima Théel.

Body oval, flattened; mouth and anus ventral; tentacles (14) 15-20 (?), retractile. Tube-feet of ventro-lateral ambulacra in a single row; mid-ventral ambulacrum naked. A single row of long, stiff papillæ along each side of body and along each of the dorsal ambulacra. Skin rather hard, the numerous rounded, perforated plates forming almost a contiguous skeleton.

Two species are known from the N.E. Atlantic, namely *Deima atlanticum* Hérourard, found at 39° 54' N., 20° 27' W., 4360 m. ("Princesse Alice"), and 28° 54' N., 28° 14' W., 2800-3000 m. ("Michael Sars"), and *D. Blakei* Théel, 43° 21' N., 10° 02' W., 2779 m. ("Princesse Alice"); elsewhere known from the West Indies, 1031-1098 m. ("Blake"). The species has also been recorded from the Indian Ocean. The two species are thus distinguished:

Dorsal papillæ 5 in each series ¹ ("Monaco", xxi., p. 32, Pls. III.-V., VIII. 26-28)	. . . . .	<i>D. atlanticum</i> Hér.
Dorsal papillæ 7-8 in each series ("Monaco", lxvi., p. 40, Pls. V. 7, VI. 5)	. . . . .	<i>D. Blakei</i> Théel

Oneirophanta Théel. (Fig. 220.)

Body elongate; mouth subterminal; tentacles 20, large, non-retractile. Tube-feet of ventro-lateral ambulacra in a double

¹ The pair of papillæ on the front and posterior end being counted among the dorsal papillæ; otherwise there are only 3 strictly dorsal papillæ in each series.

row, the mid-ventral ambulacrum with a few, more or less rudimentary tube-feet. A single series of papillæ usually alternating large and small, in each dorsal ambulacrum and along the sides of the body. Skin as in *Deima*.

Two species are known from the N.E. Atlantic, viz. *Oneiro-*

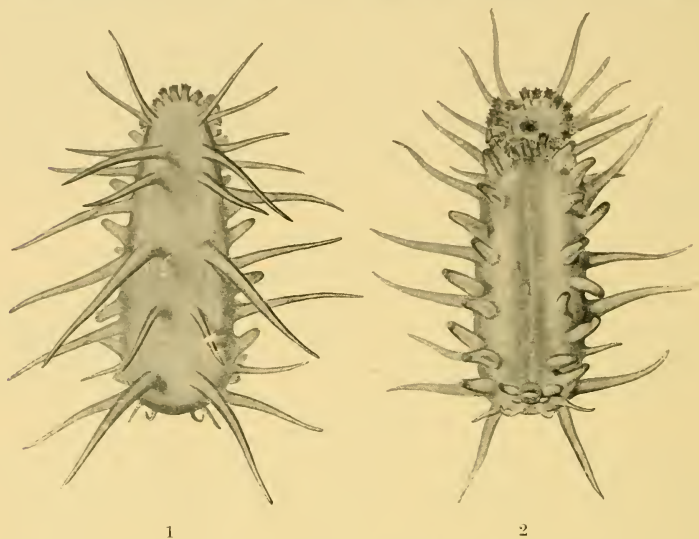


FIG. 220.—*Oneirophanta mutabilis*; dorsal (1) and ventral side (2). Diminished. (After Grieg, "*Michael Sars*" *Echinod.*)

phanta mutabilis Théel (Fig. 220), found in the Bay of Biscay and between Portugal and the Azores, ca. 1800-4870 m., also known from the Indian and the Pacific Oceans, down to ca. 5300 m.; *O. alternata* Perrier, from between Portugal and the Azores, 4060-5005 m. ("*Talisman*"). The two species are thus distinguished:

Larger and smaller papillæ alternating very regularly in both dorsal and lateral series (" <i>Talisman</i> " <i>Holoth.</i> , p. 380, Pls. XIV. 3-4, XVIII. 16-21)	<i>O. alternata</i> Perr.
Larger and smaller papillæ in dorsal and lateral series not regularly alternating (" <i>Challenger</i> ?" <i>Holoth.</i> , i., p. 62, Pls. XXI.-XXII.; " <i>Michael Sars</i> " <i>Echinod.</i> , p. 5, Pl. II.)	<i>O. mutabilis</i> Théel

[Family PSYCHROPOTIDÆ]

Body elongate, sometimes very depressed, often with a large dorsal appendage. Skin thick, gelatinous. A marginal fringe of appendages around the ventral surface of body. No non-retractile lateral papillæ. Tentacles large, with broad disk. Tube-feet

usually present also in the mid-ventral ambulacrum. Calcareous deposits pointed rods or derivatives of such, not arranged longitudinally in the dorsal papillæ. Calcareous ring incompletely developed. Gonads of various forms, simple tubes or large branched organs. Mesentery a continuous membrane, well developed also on the second intestinal loop.

Three genera known from the N.E. Atlantic.

Key to the N.E. Atlantic genera of Psychropotidæ.

1. A large dorsal appendage present 2
 No „ „ „ „ „ *Benthodytes* Théel
2. Appendage short, situated anteriorly on posterior third of body
 Euphronides Théel
- Appendage very long, situated on the posterior end of body
 Psychropotes Théel

Benthodytes Théel. (Fig. 221.)

Body more or less depressed. Mouth ventral. Anus dorsal. Tentacles 12 (?)–20. Tube-feet in a double row in the mid-ventral radius; laterally the feet are united into a web. Dorsal papillæ in variable numbers, sometimes absent. No large dorsal appendage. Deposits few, often very large, cross-shaped spinous rods with an outer central projection, or simple spinous rods.

Four species of this genus are known from the N.E. Atlantic, namely, *Benthodytes glutinosa* Perrier,¹ from off the Azores ("Talisman"), south of the Canaries, and 48° 29' N., 13° 55' W. ("Michael Sars"), in depths of 1400–3432 m.; *B. janthina* v. Marenz., from the Bay of Biscay ("Michael Sars"), off the W. coast of Morocco down to the Cape Verdes, and from the Azores, in depths of 2252–4700 m. ("Hirondelle", "Princesse Alice"); *B. lingua* Perr., from south

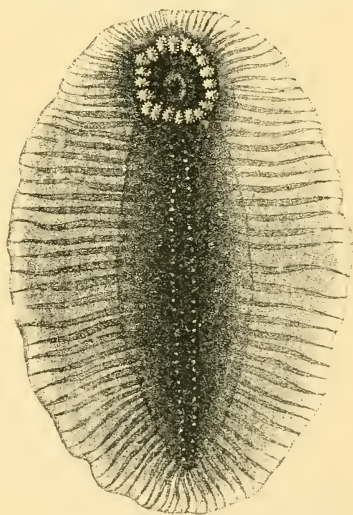


FIG. 221.—*Benthodytes typica*; ventral side. Nat. size. (After Théel, "Challenger" Holoth., i.)

¹ Hérourard ("Monaco", lxvi., p. 102) thinks that this species is identical with *B. typica* Théel; the present author has had no opportunity himself of examining these forms, but is very much inclined to agree with Hérourard in this opinion.

of the Canaries, 860-2200 m. ("Talisman"); and *B. typica* Théel (Fig. 215), from off Spain, the Canaries, and the Azores, in depths of ca. 2000-3825 m.

Key to the N.E. Atlantic species of Benthodytes.

1. Tentacles 20. Marginal web broad. Deposits simple, spinous rods, often absent 2
- Tentacles 14-15. Marginal web narrow. Deposits 4-armed, spinous rods 3
2. About 8 small, retractile papillæ in each dorsal ambulacrum ("Challenger" *Holoth.*, p. 103, Pl. XXVII. 7) *B. typica* Théel
- No dorsal papillæ ("Talisman" *Holoth.*, p. 462, Pls. XIII. 5, XX. 31) *B. glutinosa* Hér.
3. Dorsal side very vaulted, with 4 pairs of large, conical appendages and a variable number of small. Deposits slender. Colour violet. ("Monaco", vi., p. 10, Pls. I. 3, II. 4)

B. janthina v. Marenz.

Dorsal side not very vaulted, with 3 pairs of large, whip-like papillæ and a variable number of small. Deposits stout, outer projection often divided into 2-3 strong branches. Colour white to reddish ("Talisman" *Holoth.*, p. 456, Pls. XII. 1-2, XXI. 1-9) *B. lingua* Perr.

Euphronides Théel. (Fig. 222.)

(Syn. *Triconus* Hérourard.)

Body more or less depressed, especially anteriorly. Skin gelatinous. Mouth and anus ventral. Tentacles 10-18, increas-

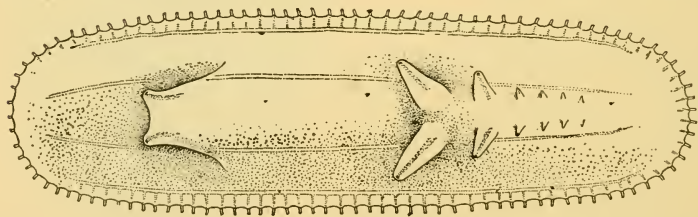


FIG. 222.—*Euphronides cornuta*, dorsal side; the anterior end is to the right. Reduced. (After Verrill, "Albatross" Rep.)

ing in number with age. Dorsal side anteriorly with 4-6 pairs of papillæ, the posterior ones the largest. Dorsal unpaired appendage not very long, usually a considerable distance from the posterior end. Mid-ventral radius with a double row of tube-feet; lateral tube-feet small and numerous, forming a continuous narrow marginal fringe. Deposits cross-shaped bodies, those of the ventral much smaller than those of the dorsal side.

Five species of this genus are known from the N.E. Atlantic, namely *Euphr. anchora* Hérourard, 31° 45' N., 42° 42' W., 3465 m. ("Princesse Alice"; only one specimen known); *E. cornuta* Verrill (Syn. *E. auriculata* Perr.) (Fig. 222), from off the Canaries to off Spain, 1918-2300 m. ("Talisman", "Michael Sars"), also known from off the east coast of N. America; *E. Kerhervei* (Hér.) (Syn. *Psychropotes Kerhervei* Hérourard), from Azores to Canaries, 3825-5005 m. ("Princesse Alice"); *E. Talismani* Perrier, 38° N., 29° 25' W., 2155-2220 m. ("Talisman"); and *E. violacea* Perr., from off the Canaries and Portugal, 1180-2210 m. ("Talisman").¹

Key to the N.E. Atlantic species of Euphronides.

1. Outer projection of larger deposits ending in four backwardly curved hooks, like an anchor ("Monaco", lxvi., p. 103 Pls. I. 22-30, VI. 3) *E. anchora* Hér.
Outer projection of deposits not anchor-like 2
2. Five or six pairs of anterior dorsal appendages, the two hindmost pairs much larger ("Talisman" *Holoth.*, p. 434, Pls. XIII. 1-2, XX. 12-13) *E. cornuta* Verr.
Four pairs of anterior dorsal appendages 3
3. The hindmost pair of dorsal appendages not enlarged ("Monaco", xxi., p. 27, Pl. IV. 1-9; lxvi., p. 107, Pl. III. 4-5) *E. Kerhervei* (Hér.)
The hindmost pair of dorsal appendages much larger 4
4. Ventral deposits very numerous, small, arms slightly bent; dorsal deposits very large, ca. 1 mm. in diameter, spines on arms rather fine and small, excepting the basal spine ("Talisman" *Holoth.*, p. 441, Pl. XX. 15; "Monaco", xxi., p. 30, Pl. II. 19-22) *E. Talismani* Perr.
Ventral deposits few, small, arms nearly flat; dorsal deposits ca. 0.55-0.95 mm. in diameter, spines on arms rather coarse ("Talisman" *Holoth.*, p. 438, Pl. XX. 14) *E. violacea* Perr.

Psychropotes Théel. (Fig. 223.)

Body flat anteriorly, rising in height posteriorly, terminating in a long tail-like prolongation which issues from the dorsal side near the posterior end. Mouth and anus ventral; tentacles 10-18. Usually a double row of tube-feet along the mid-ventral ambulacrum. Lateral tube-feet large, conical, only the hindmost more or less distinctly united by a web. Deposits cross-shaped bodies, often different in the outer and inner dermal layer; those of the ventral smaller than those of the dorsal surface.

¹ It seems doubtful whether *E. violacea* is really distinct from *E. Talismani*.

The two genera *Euphronides* and *Psychropotes* are not very sharply separated, a form like *Kerhervei* Hér. being intermediate, though apparently rather an *Euphronides* than a *Psychropotes*. The long tail probably is a swimming apparatus.

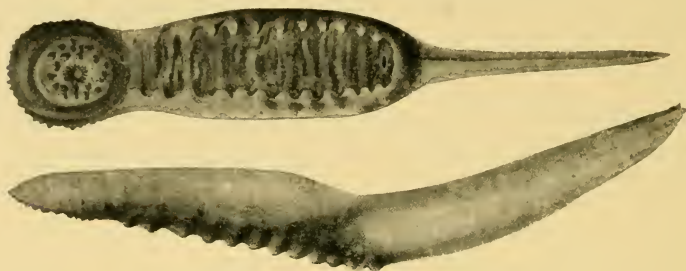


FIG. 223.—*Psychropotes Grimaldii*; ventral side (upper) and in side view (lower figure). Much reduced. (After Hérourard, "Monaco", xxi.)

Three species known from the N.E. Atlantic, viz. *Psychropotes buglossa* Perr., from the Bay of Biscay and off the Canaries, 2110-5005 m. ("Talisman", "Princesse Alice"); *Ps. fucata* Perr., 43° 15' N., 21° 40' W., 4165 m. ("Talisman"); and *Ps. Grimaldii* Hérourard, off the Azores, 4020 m. ("Princesse Alice").

Key to the N.E. Atlantic species of Psychropotes.

1. Mid-ventral radius naked ("Monaco", xxi., p. 25, Pl. III. 1-2)
Ps. Grimaldii Hér.
- Mid-ventral radius with a double row of small tube-feet 2
2. Dorsal deposits of one kind only, cross-shaped bodies with short central spine and basal spine of arms short ("*Talisman*" *Holoth.*, p. 453, Pl. XX. 29-30) *Ps. fucata* Perr.
- Dorsal deposits of two kinds—in the outer layer large, with strong central outer projection and basal spine of arms nearly as large as the central projection; in inner layer simple crosses without central projection ("*Talisman*" *Holoth.*, p. 445, Pls. XIII. 3-4, XX. 16-28) *Ps. buglossa* Perr.

[Family PELAGOTHURIIDÆ]

Body ovoid, without tube-feet, but with a circular disk round the anterior end, supported by long rays. Tentacles bifurcating, slightly branched. Calcareous bodies absent.

The only genus known, *Pelagothuria* Ludwig, is represented in the Atlantic by one species, *Pelagoth. Bouvieri* Hérourard; the only known specimen was taken at the surface at 31° 38' N., 42° 38' W. ("Princesse Alice"); the species might well be expected to occur also off the Irish west coasts.

Another pelagic Holothurian, *Planktothuria diaphana* Gilchrist,¹ agrees with *Pelagothuria* in the peculiar shape of the tentacles, and therefore may perhaps also belong to this family, in spite of the conspicuous differences from *Pelagothuria* (no free circular disk, presence of rudimentary tube-feet, etc.). It is known only from off South Africa, but as a deep-sea pelagic organism may well be expected to have a wide distribution, and thus perhaps to occur also in the N. Atlantic deep sea.

II. Order. ASPIDCCHIOTA Grube.

Tube-feet present; tentacles shield-shaped. No retractor muscles. Respiratory trees present. Mesentery of the posterior intestinal loop attached in the right ventral interradius. Calcareous deposits simple, pointed rods, tables, buttons, etc. Body cylindrical or flattened, bilaterally symmetrical.

All feeding on bottom material, with which they fill their alimentary canal, shovelling it into the mouth by means of their peltate tentacles.

This order comprises three families, all represented in the British seas.

Key to the families of the Aspidochiota.

1. Tentacle ampullæ absent I. *Synallactidæ*
- " " present 2
2. Gonads on both sides of the dorsal mesentery II. *Stichopodidæ*
- Gonads only on the left side of the dorsal mesentery

III. *Holothuriidæ*

I. Family SYNALLACTIDÆ

Tentacle ampullæ absent. Gonads variously developed. Respiratory trees usually not connected with the alimentary canal through a rete mirabile. Stone canal usually in connection with the body wall, sometimes opening outwards through the body wall. No Cuvierian organs. Deposits tables; C-shaped bodies may be present and, very rarely, buttons.

Mainly deep-sea forms of rather large size. Some of them (*e.g.* *Pseudostichopus*) have the habit of agglutinating foreign bodies—sponge spicules, Pteropod shells, Globigerinas, etc.—to their skin; the tube-feet of these forms are generally much reduced, and the calcareous bodies are also very much reduced or totally absent.

Two genera, *Mesothuria* Ludw. and *Bathyplores* Östergren,

¹ J. D. F. Gilchrist, "Planktothuria diaphana, g. and sp. n.", *Quart. Journ. Micr. Sc.*, vol. 64, 1920.

are known from the British seas, but six more may likewise be expected to be represented there, viz. *Benthothuria* R. Perrier, with the species *funebria* Perr., found off the Moroccan coast, 782-1230 m. ("Talisman"); *Gephyrothuria* Koehler and Vaney (Syn. *Himasthlephora* H. L. Clark), with the species *G. europeensis* Hérourard, from 43° 45' 30" N., 9° 41' W., 2320 m. ("Princesse Alice"; only one specimen known); *Paroriza* Hérourard, with two species (see below, p. 386); *Pælopatides* Théel, with two species (see below, p. 388); *Pseudostichopus* Théel, with seven species (see below, p. 386); *Synallactes* Ludwig, with the species *S. crucifera* Perrier, from 30° 3' N., 14° 2' W., 2212 m. ("Talisman"; only one specimen known).

Key to the genera of Synallactidae known from or likely to be represented in the British seas.

1. Genital tubes in a single bundle to the left of the dorsal mesentery.
 Tube-feet covering nearly the whole body. Deposits 3- or 4-
 radiate tables 1. *Mesothuria* Ludw.
 Genital tubes in a double bundle, one to each side of dorsal
 mesentery 2
2. Anal opening in a vertical furrow, or situated at the base of a
 caudal prolongation¹ 7
 Anal opening not in a furrow nor at the base of a caudal pro-
 longation 3
3. A marginal fringe along sides of body, which is rather flattened,
 with a distinct ventral sole 4
 No marginal fringe along sides of body, which is more or less
 cylindrical, without distinct ventral sole 6
4. Body very broad and flattened; marginal fringe strongly developed
Pælopatides Théel
 Body not very broad and flattened; marginal fringe not strongly
 developed 5
5. Deposits cruciform 2. *Bathyplores* Östergren
 „ absent (?)² *Benthothuria* Perr.
6. Ventral tube-feet and dorsal papillæ disposed regularly along
 the ambulacra. Deposits cruciform, with a simple spire
 (Fig. 224, 9) *Synallactes* Ludw.
 Tube-feet and papillæ irregularly distributed; no deposits
Paroriza Hér.
7. Anal opening in a vertical furrow. Skin usually covered with foreign
 bodies; tube-feet all rudimentary . . . *Pseudostichopus* Théel
 Anal opening at the base of a caudal prolongation. Skin not
 covered with foreign bodies. A series of large papillæ along
 each dorsal ambulacrum *Gephyrothuria* Koehler and Vaney

¹ Also in *Paroriza* the anal opening may, on contraction, lie in a more or less distinct longitudinal furrow.

² It may perhaps be questionable whether *Benthothuria* can really be maintained as different from *Bathyplores*.

1. *Mesothuria* Ludwig.(Syn. *Allantis* Hérourard ; *Zygothuria* Perrier.)

Body usually cylindrical, slightly attenuating towards both ends, without marginal fringe. Twelve to twenty tentacles. Mouth terminal. Genital organs only on the left side of the dorsal mesentery. Skin thin. Calcareous deposits tables ; no C-shaped spicules. Development unknown.

Three species of this genus are known from the British seas, and six more may be expected to occur there also, viz. *Mesothuria candelabra* Hérourard, Bay of Biscay, 4870 m. ("Princesse Alice" ; only some pieces of skin have been found) ; *M. connectens* (Perr.) (Syn. *Zygothuria connectens* Perr.), off the Canaries, 1975-2518 m. ("Talisman") ; *M. expectans* Perr., 44° 20' N., 19° 31' W., 4255 m. ("Talisman" ; only one specimen known) ; *M. maroccana* Perr., from off the Moroccan coast and between Spain and the Azores, ca. 2000-3120 m. "Talisman", "Michael Sars") ; *M. Murrayi* Théel, var. *grandipes* Hérourard, from between the Azores and Madeira, ca. 1500-2180 m. ("Princesse Alice") ; *M. rugosa* Hérourard, off the Cape Verdes, 3890 m. ("Princesse Alice" ; only one specimen known).

Key to the species of Mesothuria known from or likely to occur in the British seas.

1. Vento-lateral ambulacra with no distinct series of larger tube-feet 2
- Vento-lateral ambulacra with one or two distinct series of larger tube-feet¹ 5
2. Deposits of 4-radiate type, with spire composed of 4 rods . . . 3
- " 3- " " " " " 3 " . . . 4
3. Spire of tables with a crown of several thorns ; tables of tube-feet like those of the skin . . . 1. *M. intestinalis* (Ascan.)
- Spire of tables with a crown of only 4 thorns ; tables of tube-feet reduced, less developed than those of the skin (Fig. 224, 4-5) 2. *M. Verrilli* (Théel)
4. Spire regular, the three component rods equally developed, ending in 3-5 thorns each ; the disk regular with 6 peripheral holes (Fig. 224, 1) ("*Talisman*" *Holoth.*, p. 312, Pl. XVI. 32-35) *M. maroccana* Perr.
- Spire irregular, the three component rods unequally developed ;

¹ The position of *M. candelabra* in one or other of these two groups is uncertain, only the calcareous deposits being known, but judging from these it would seem to be near to *M. connectens*, and is therefore placed in the same group as this species. *M. expectans* is possibly only the young of *Paroriza Prouhoi*.

disk usually irregular (Fig. 224, 6-7) ("Monaco", lxvi., p. 19, Pls. I. 11-21, II. 1-2) *M. rugosa* Hér.

5. A double series of long tube-feet in each ambulacrum, except the mid-ventral; the whole body otherwise covered with tube-feet, small on the ventral, larger on the dorsal side. Deposits unknown (? absent) ("Talisman" *Holoth.*, p. 317)

M. expectans Perr.

A double series of larger tube-feet in the latero-ventral ambulacra; also in the anterior part of body the dorsal tube-feet show a linear arrangement. Deposits with spire composed of 3 rods ("Monaco", lxvi., p. 15, Pl. IV. 7-9)

M. Murrayi, var. *grandipes* Hér.

Only a single series of larger tube-feet in lateral ambulacra 6

6. Deposits exclusively of the 3-radiate type, with 3 component rods in the spire 3. *M. lactea* (Théel)

Deposits partly of the 3-radiate, partly of the 4-radiate, type 7

7. Rods of the spire ending each in a smooth point (Fig. 224, 8); disk with numerous holes ("Talisman" *Holoth.*, p. 327)

M. connectens Perr.

Rods of the spire ending each in a long, serrate point (Fig. 224, 10).

Disk usually with 7-8 peripheral holes ("Monaco", lxvi., p. 17, Pl. I. 1-10) *M. candelabra* Hér.

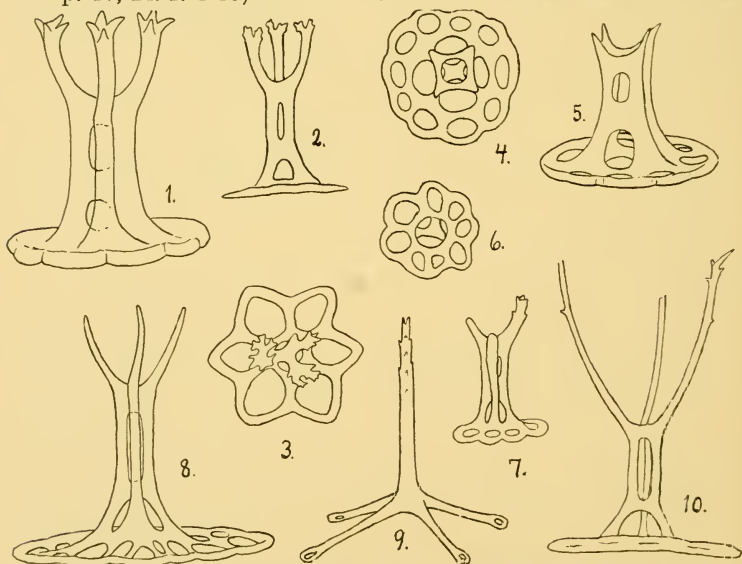


FIG. 224.—Calcareous deposits (tables) of *Mesothuria maroccana* (1); *M. Murrayi* (2-3, side view and from above); *M. Verrilli* (4-5, from above and side view); *M. rugosa* (6-7, from below and side view); *M. connectens* (8); *M. candelabra* (10); and *Synallactes crucifera* (9). 1, 4-5, 8-9. $\times 240$. Magnification not stated on the originals of the other figures. (After Perrier, "Talisman" *Holoth.* (1, 4-5, 8-9); Théel, "Challenger" *Holoth.*, ii. (2-3); Hérouard, "Monaco", lxvi. (6-7, 10).)

1. *Mesothuria intestinalis* (Ascanius). (Fig. 228, 3.)

(Syn. *Holothuria intestinalis* Ascanius ; *Allantis intestinalis* (Asc.) Hérourard.)

Mouth subventral, anus posterior. Tentacles 20 in adult, fewer in younger specimens. Tube-feet most strongly developed in the ventro-lateral ambulacra, but no distinct longitudinal series there of larger tube-feet ; on the dorsal side they are fewer and smaller, and especially they are very scarce along the mid-ventral radius, which appears almost naked. The calcareous deposits (Fig. 225), which lie very closely in the skin, are tables of the 4-radiate type, with a spire built of 4 rods, ending in a crown of several thorns ; disk often with some small holes outside the primary circle of peripheral holes. In quite small specimens the spire may be composed of only 3 rods. Tables of the tube-feet well developed, like those of the skin. Colour in life greyish-white, often with a faint pink or violet tint. Often pale brown in alcohol. Grows to a length of ca. 30 cm.

The species is hermaphrodite, but male and female products

are not found ripe at the same time. Eggs large and yolky ; the development, therefore, probably direct, without a pelagic larval stage. It lives on muddy bottom and usually covers itself with shell fragments and other bottom material. It is rather difficult to preserve, as it usually eviscerates itself during capture.

In British seas this species has been found repeatedly off S.W. Ireland, in ca. 340-1350 m. ; it is further recorded from Kilbrennan Sound, the Clyde, and the Minch, in ca. 50-100 m. depth. The species is elsewhere distributed from the Murman coast to the Azores and the Mediterranean. Bathymetrical distribution ca. 20-2000 m.

2. *Mesothuria Verrilli* (Théel).

(Syn. *Holothuria Verrilli* Théel ; *Allantis intestinalis*, var.

Verrilli (Théel) Hérourard ; *Holothuria Roulei* Koehler.)

Differs from the preceding species in the tube-feet being smaller and very closely set in the posterior part of body, which

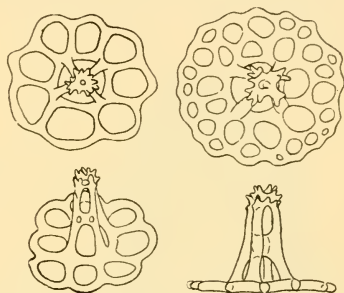


FIG. 225.—Calcareous deposits (tables) of *Mesothuria intestinalis*, seen from above and in side view. $\times 145$. (From *Danmark's Fauna*.)

thereby gets an almost shaggy appearance ; on the contrary the tube-feet are scarcer on the anterior end of the trivium than in *intestinalis*. Spire of the tables ending in four simple points (Fig. 224, 4-5) ; tables of the tube-feet reduced, smaller than those of the skin. Colour in life light grey, with a tint of violet. Grows to about the same size as *intestinalis*.

It appears that this species does not cover itself with foreign bodies, the skin of preserved specimens being clean and white. It appears to be unisexual.

In British seas this species has been found off S.W. Ireland, in ca. 990-1765 m. (" Helga "). It is elsewhere known from the Bay of Biscay to the Azores, the Canaries, and the Mediterranean, and also from the West Indies. Bathymetrical distribution ca. 280-2520 m.



FIG. 226.—*Mesothuria lactea*; ventral side. Somewhat reduced. (After Hérourard, "Monaco", xxi.)

3. *Mesothuria lactea* (Théel).

(Fig. 226.)

(Syn. *Holothuria lactea* Théel ; *Zygothuria lactea* (Théel) Perrier ;
(?) *Holothuria aspera* Bell.¹)

Body rather flattened, broader in the posterior end. Tentacles 15-20. A single series of rather distant, conical tube-feet in the ventro-lateral ambulacra, none in the mid-ventral radius. Dorsal papillæ few or wholly wanting. Deposits (Fig. 227) of the 3-radiate type, the spire ending in 3 smooth points, the disk with six regular peripheral holes. In the basal part of the tube-feet supporting rods occur ; in the outer part more or less reduced tables. Colour in life whitish or grey. Grows to a size of ca. 15 cm. Apparently unisexual.

A form with the spire of the tables ending in a simple point, and with usually a number of small holes outside the usual

¹ It seems very probable that the *Holothuria lactea* of Bell is really identical with this species, the star-shaped spicules of that species (*Catalogue Brit. Ech.*, p. 50) being, as pointed out by Massy, "very like the beautiful wide-meshed disks of *M. lactea*, if the deposits examined had the outer rings of the tables broken away or not developed". Such spicules were actually found by Massy in portions of the perisome of one specimen of *M. lactea*.

peripheral holes of the disk, has been designated Var. *oxysclera* Perrier.

In British seas this species has been found off S.W. Ireland,

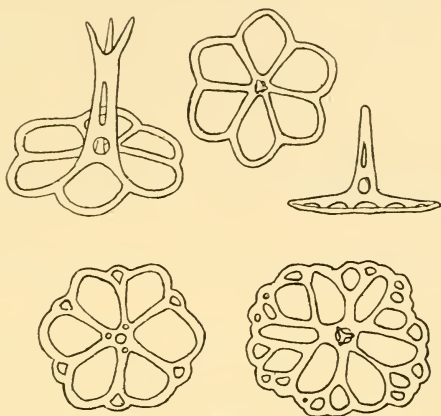


FIG. 227.—Deposits of *Mesothuria lactea*. $\times 275$.
(After Perrier, "Talisman" *Holoth.*)

in depths of ca. 1200-1765 m. ("Helga"). It is elsewhere distributed from the Bay of Biscay to the Azores and Cape Verdes, and also recorded from the Indo-Pacific. The bathymetrical distribution is ca. 700-2100 m.

2. *Bathyplores* Östergren.

Body flattened on the ventral side, which forms a distinct sole, a more or less conspicuous fringe limiting it from the dorsal side. Skin rather thick. Mouth ventral. Fifteen to twenty tentacles. Tube-feet well developed on ventral side, but often lacking in the mid-ventral radius; papillæ on the dorsal side. Deposits cruciform, with spire; C-shaped spicules may be present. Gonads on both sides of dorsal mesentery.

One species known from the British seas, but two more may possibly occur there also, namely *Bathyplores Pourtalesii* Théel (Syn. *B. bipartitus* Hér.),¹ found off the Cape Verdes, 134-1477 m. ("Princesse Alice"), also known from the West Indies, 375-1320 m.; *B. reptans* Perr., 30° 3' N., 14° 2' W., 2212 m. ("Talisman").

¹ According to Miss Deichmann, who has had the opportunity of studying more closely the *Bathyplores Pourtalesii*.

Key to the species of Bathyplores known from or likely to occur in the British seas.

1. Tube-feet of latero-ventral ambulacra very large ; mid-ventral radius with very numerous small tube-feet, covering the whole space between the two lateral series of large tube-feet (" *Monaco* ", lxvi., p. 34, Pl. V. 8) . *B. Pourtalesii* (Théel)

Tube-feet of latero-ventral ambulacra not very large ; mid-ventral radius usually naked, sometimes with a variable number of tube-feet like those of the lateral series 2

2. A series of small papillæ between the latero-ventral tube-feet and the marginal fringe, mainly in the posterior half of the body (" *Talisman* " *Holoth.*, p. 332, Pls. XII. 3-4, XVIII. 1-9)

B. reptans Perr.

The space between the latero-ventral tube-feet and the marginal fringe without small papillæ . . . 1. *B. natans* (M. Sars)

1. *Bathyplores natans* (M. Sars). (Fig. 228, 2.)

(Syn. *Stichopus natans* M. Sars ; *Stichopus Tizardi* Théel ; *Bathyplores fallax* Östergren.)

Tentacles 20 in the adult, fewer in younger specimens. Tube-feet of the latero-ventral ambulacra in a double series, or more,

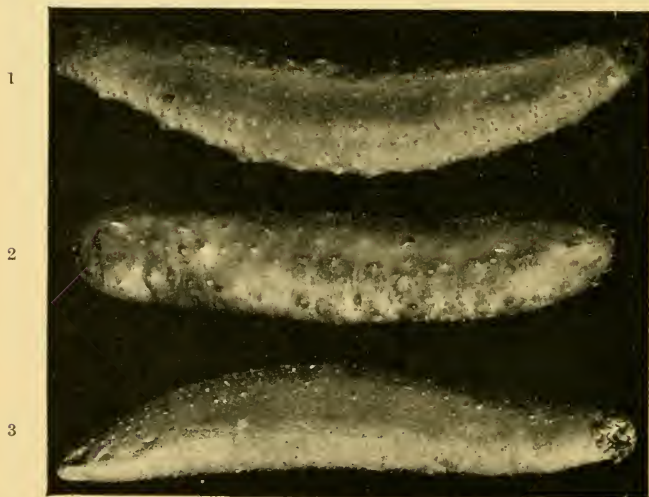


FIG. 228.—1. *Stichopus tremulus*, side view. 2. *Bathyplores natans*, dorsal side. 3. *Mesothuria intestinalis*, side view. All reduced. (From *Danmark's Fauna*.)

well developed, but not unusually large ; the mid-ventral radius usually entirely naked, but sometimes a few scattered tube-feet

occur there, and sometimes they are as numerous as, or even more numerous than, in the lateral ambulacra. On the dorsal side scattered, more or less distinctly serially arranged, larger papillæ. Calcareous deposits (Fig. 229) cruciform bodies, with one or more holes in the end of each branch; in the centre a high spire formed by 4 rods connected by a variable number of cross beams. C-shaped spicules may be found in the skin or in the inner organs. Colour in life yellowish, faint reddish, or brownish; yellow spots between and on the tentacles. Grows to a size of ca. 15 cm.

The variable development of the tube-feet on the ventral sole has caused the establishment of the supposed species *B. Tizardi* and *fallax*; but as all transitional forms may be found, even in one and the same locality, the said forms must be regarded only as individual variations of *B. natans*.



FIG. 229.—Calcareous deposits of *Bathyplores natans*. $\times 145$.
(From *Danmark's Fauna*.)

1-2. Cruciform bodies, from above. 3. Same, in side view. 4. Smaller form of cruciform bodies, with branches partly connected by transverse rods. 5. C-shaped spicule.

It is unisexual. Eggs large, yolky; the development, therefore, probably direct. An observation from Japan seems to indicate that it is brood-protecting, the male carrying the eggs attached to its tentacles. It swims by means of up and down movements. It has the peculiarity (probably common to various species of the genus) that the skin easily breaks up along the interradii. If kept alive for a little while, the skin is apt to dissolve into slime. It lives on muddy bottom, feeding—like all these deep-sea Holothurians—on detritus.

In British seas this species has been found in the Faroe Channel ("Triton") and off the Irish west coast ("Flying Falcon", "Helga"), 1100-1350 m. It is elsewhere distributed from Lofoten to the Cape Verdes; also recorded from the West Indies and from Japan. Bathymetrical distribution ca. 200-1600 m.

[*Paroriza* Hérourard.]

Body cylindrical, only slightly flattened on the ventral side, which does not form a ventral sole and is not separated from the dorsal side by a marginal fringe. Mouth ventral; anus sometimes in a more or less distinct longitudinal furrow. Twenty tentacles. Tube-feet well developed, but not regularly arranged; those of the dorsal side slender papillæ. Skin naked. No calcareous deposits. Gonads on both sides of the dorsal mesentery.

Two species known from the N.E. Atlantic, viz. *Paroriza Prouhoi* Hérourard, from the Bay of Biscay and off the Azores, 4360-4380 m. ("Princesse Alice"); and *P. pallens* (Koehler) (Syn. *Stichopus pallens* Koehler), from Bay of Biscay, 1300 m. ("Caudan"). The two species are thus distinguished:

Mid-ventral radius without tube-feet ("Monaco", xxi., p. 24,	
Pl. VIII. 1; lxvi., p. 29, Pl. II. 3-4)	<i>P. Prouhoi</i> Hér.
Mid-ventral radius with some scattered tube-feet (<i>Echinod.</i>	
"Caudan", p. 111, Figs. 1, 45)	<i>P. pallens</i> (Koehler)

Both species are large forms, up to 22-23 cm. An Actinian, *Sicyopus commensalis* Gravier, has been found attached to the skin, above the mouth, in *P. Prouhoi*.

[*Pseudostichopus* Théel.] (Fig. 230.)

Body cylindrical or slightly flattened on the ventral side, which does not form a ventral sole and is usually not separated from the dorsal side by a marginal brim. Mouth subterminal; tentacles 16-20. Tube-feet very small and numerous, often apparently double or triple, usually concealed by the close coat of foreign bodies—sponge spicules, Pteropod shells, Foraminifera, etc.—which cover the whole skin. Retractor muscles developed in the posterior end of the four paired ambulacra, not on the mid-ventral. To these it is due that the posterior end is usually contracted on preservation, forming a longitudinal furrow at the ventral end of which the anus is situated. Calcareous deposits rare or absent. Gonads on both sides of the dorsal mesentery.

Deep-sea forms of moderate or rather small size.

Seven species are known from the N.E. Atlantic, namely, *Pseudostichopus atlanticus* R. Perrier, from 42° 19' N., 23° 36' W., 4060 m.; *Ps. depressus* Hérourard, 39° 54' N., 20° 17' W., 4360 m. ("Princesse Alice"; only one specimen known) (Fig. 230); *Ps. globigerinæ* Hérourard, Bay of Biscay, 4380 m. ("Princesse

Alice"); *Ps. lapidus* Hér., off the Azores, 4020 m. ("Princesse Alice"; only one specimen known); *Ps. Marenzelleri* Hér., 36° 54' N., 20° 46' W., 4400 m. ("Princess Alice"); *Ps. occul-*

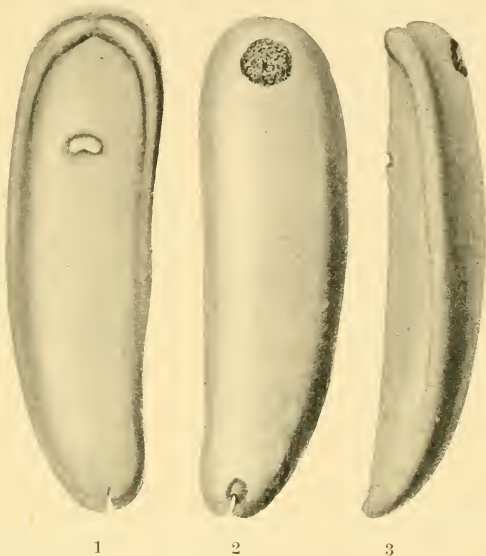


FIG. 230.—*Pseudostichopus depressus*; dorsal (1) and ventral side (2) and side view (3). The small depression in the anterior third of body seen in (1) and (3) is the madreporite. Somewhat reduced. (After Hérouard, "Monaco", xxi.)

tatus Marenzeller, off N.W. Spain, ca. 500 m. ("Hirondelle"), also found in the Mediterranean, in depths of 415-1445 m.; *Ps. villosus* Théel, 37° 16' N., 20° 11' W., 4275 m. ("Princesse Alice"), otherwise of cosmopolitan distribution, ca. 2600-5300 m.

*Key to the N.E. Atlantic species of Pseudostichopus.*¹

1. No foreign particles adhering to the skin. Large, round, solid deposits with warty or spinous surface present in the skin of ventral side ("Talisman" *Holoth.*, p. 333, Pl. XVII. 15-20). *Ps. atlanticus* Perr.
Body covered by foreign particles; deposits, if present, not large, solid bodies 2
2. A broad, thick marginal brim in anterior half of body; madreporite large, externally visible as an oval impression on the dorsal side. No calcareous deposits ("Monaco", xxi., p. 15, Pl. II. 15-18) *Ps. depressus* Hér.
No thick marginal brim, or, at most, an indication of one; madreporite not large and visible externally 3

¹ This key has in the main been worked out by Miss Deichmann.

3. Only 4 tube-feet along each dorsal ambulacrum ("Monaco", lxvi., p. 26, Pl. IV. 5) *Ps. lapidus* Hér.
Dorsal tube-feet more numerous¹ 4
4. Tube-feet very scarce or absent on the mid-ventral radius; skin covered by *Globigerina* 5
Tube-feet numerous on mid-ventral radius; skin covered by Pteropod shells, sponge spicules, or other foreign bodies 6
5. Tube-feet on the anal lobes placed in tufts on small warts; no lateral series of larger tube-feet ("Monaco", lxvi., p. 23, Pl. IV. 6) *Ps. globigerinæ* Hér.
Tube-feet on anal lobes not in tufts on warts; a series of larger tube-feet along each side of body ("Monaco", lxvi., p. 25; xxi., p. 14, Pl. II. 4-14, as *Ps. occultatus* Marenz.) *Ps. Marenzelleri* Hér.
6. Tube-feet on nearly equal size. Five pieces in calcareous ring ("Challenger" *Holoth.*, ii., p. 170) *Ps. villosus* Théel
Tube-feet along radii larger. Ten pieces in calcareous ring (Marenzeller *Echinodermen d. ostl. Mittelm.*, 1893, p. 15. Taf. IV. 9) *Ps. occultatus* Marenz.

[*Pælopatides* Théel.²]

Body very broad and flattened, the ventral side forming a distinct sole, separated from the dorsal side by a strongly developed marginal brim. Mouth ventral, anus dorsal; tentacles 16(?)–20. Tube-feet in a double row in posterior part of mid-ventral radius. Deposits present—three-armed bodies with the arms widened at the end, and with a central spire—or absent. Gonads on both sides of dorsal mesentery.

Two species known from the N.E. Atlantic, namely *Pælopatides atlantica* Hérourard, off the Azores, 4020 m. ("Princesse Alice"; only one specimen known); and *P. grisea* Perrier,³ from off the Canaries and between the Azores and Portugal, 1918–4060 m. ("Talisman"). The two species are thus distinguished:

Deposits absent; a median furrow along the dorsal side. Dorsal papillæ not regularly arranged ("Monaco", xxi., p. 16)

P. atlantica Hér.

Deposits present, 3-radiate bodies with arms bending inwards and with central projection about one-third as long as the arms.

Dorsal papillæ regularly arranged in pairs ("Talisman" *Holoth.*, p. 361) *P. grisea* Perr.

¹ In order to see the tube-feet it may be necessary to clean the skin for the foreign bodies; placing the specimens in fresh water will make the tube-feet swell, thus making them more distinct.

² This name is often incorrectly given as *Pelopatides*.

³ In the opinion of Hérourard this species is identical with *Pælopatides confundens* Théel. According to information received from Miss Deichmann it is probably identical with the West Indian *P. Agassizii* Théel (which Ludwig erroneously identified with *P. confundens*).

II. Family STICHOPODIDÆ

Tentacle ampullæ present. Gonads on both sides of the dorsal mesentery. Respiratory trees usually connected with the alimentary canal through a rete mirabile. Stone canal usually connected with the body wall. No Cuvierian organs. Deposits tables and derivatives of pointed rods; often C-shaped spicules; rarely buttons may occur.

One genus known from the British and N.E. Atlantic seas.

1. *Stichopus* Brandt.

(Syn. *Parastichopus* H. L. Clark.¹)

Body cylindrical or with ventral side more or less flattened, with numerous tube-feet; dorsal side vaulted, with papillæ. Twenty tentacles. Deposits tables; C-shaped bodies may be present, rarely also buttons; no minute granules.

Two species known from the British seas and from the N.E. Atlantic.

Key to the British and N.E. Atlantic species of Stichopus.

Body nearly cylindrical; colour in life red. Besides the disks also numerous star-shaped spicules present 1. *St. tremulus* (Gunn.)

Body flattened; colour in life brownish with white spots. Star-shaped spicules less numerous, and chiefly in the radii

2. *St. regalis* (Cuvier)

1. *Stichopus tremulus* (Gunnerus). (Fig. 228, 1.)

(Syn. *Holothuria tremula* Gunnerus; *H. elegans* O. Fr. Müll.; *H. ealcareia* M. Sars; *Stichopus Griegi* Östergren; *Stichopus Richardi* Hérourard; *Parastichopus tremulus* (Gunn.) H. L. Clark.)

Body nearly cylindrical, attenuating towards the ends. Mouth subventral. The circle of tentacles surrounded by a fringe formed by the anterior papillæ, which are united by a web. Tube-feet of the mid-ventral ambulacrum small, rather sparse and scattered; in the lateral ambulacra more crowded, larger, more papilla-like, passing gradually into the papillæ on the sides of the body; the papillæ of the dorsal side again smaller. Calcareous deposits (Fig. 231) very numerous; disks of tables with serrate edge, rods of the spire connected by 2 sets of cross beams. In the deeper

¹ The genus *Parastichopus* established by H. L. Clark for *St. tremulus* does not seem sufficiently warranted, at least for the present.

dermal layers numerous star-shaped bodies and coarser spinous rods of various shapes and sizes. No C-shaped spicules. Colour in life a magnificent red on the dorsal side, sometimes all over the body, but more usually the ventral side is whitish. Small black spots in variable numbers scattered in the red. On preservation in alcohol the red colour disappears completely. Grows to a considerable size, up to ca. 50 cm. length, and is, next *Cucumaria frondosa*, the largest of the British and North Atlantic Holothurians.

Development unknown; the very small eggs, however,

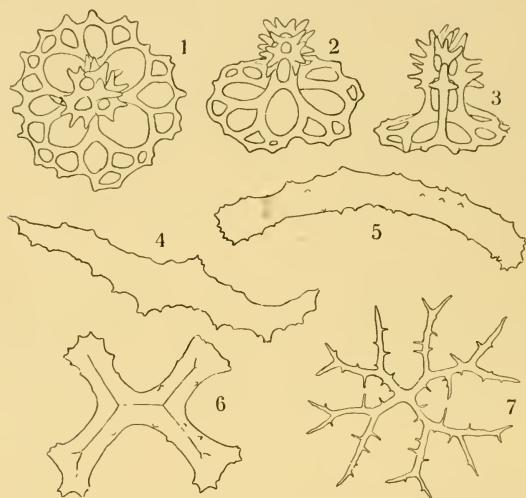


FIG. 231.—Calcareous deposits of *Stichopus tremulus*. $\times 200$.
(From *Danmark's Fauna*.)

1-3. Tables, from above and in side view. 4-6. Spinous rods. 7. Star-shaped body.

would tend to indicate that it may have a pelagic larva. It is very apt to eviscerate on capture. Various parasites occur in this species, namely, besides the very remarkable worm-shaped Gastropod *Enteroxenos Oestergreni* Bonnevie, several species of Planarians, living partly in the intestine, partly in the body cavity.

In British seas this species is abundant and widely distributed off the west coast of Ireland (usually found together with *Spatangus Raschi*), in depths of ca. 140-1280 m.; also known from the Rockall and the Lousy Banks. It is elsewhere distributed from Finmark to Skagerrack in Scandinavian seas, and to the Bay of Biscay and the Canaries. Bathymetrical distribution ca. 20-1900 m.

2. *Stichopus regalis* (Cuvier). (Fig. 232.)

(Syn. *Holothuria regalis* Cuvier ; *Hol. columnæ* Cuvier ;
Hol. triquetra Delle Chiaje.)

Body flattened on the ventral side, which forms a distinct sole. Margin of body set with large papillæ forming a rather

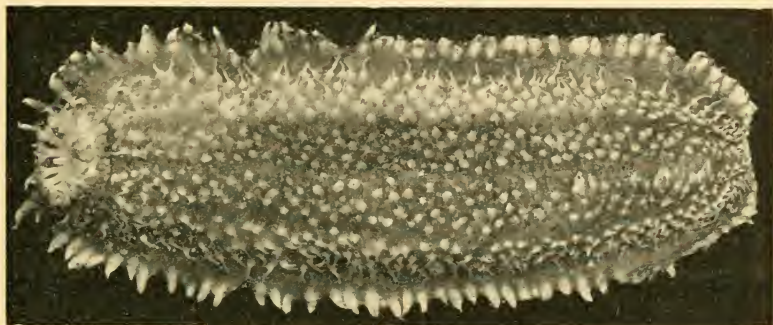


FIG. 232.—*Stichopus regalis*, ventral view. Somewhat reduced.

conspicuous brim, which continues round the anterior end, above the ventrally situated mouth. Ventral side with three more or less distinct series of tube-feet ; dorsal side with large, more or

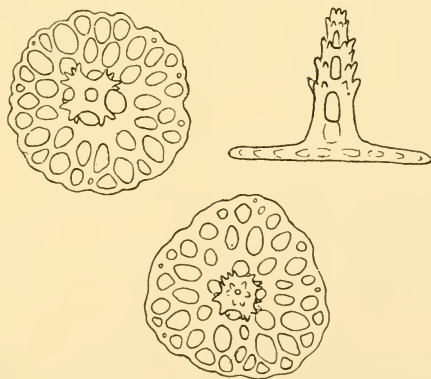


FIG. 233.—Tables of *Stichopus regalis*, from above and inside view. $\times 245$.

less distinctly serially arranged tubercles, each ending in a conical papilla. Calcareous deposits tables, elongate, flattened rods, and star-shaped bodies, the latter chiefly in the radii, near the longitudinal muscles. The disk of the tables large, with the edge entire ; rods of the spire connected by 3-5 sets of cross beams (Fig. 233). Colour in life brownish, often with large,

rounded, white spots on the dorsal side ; the ventral side lighter coloured. Grows to ca. 30 cm. length.

This species is less apt to eviscerate on capture ; can even live a fairly long time in aquaria. As in several other tropical species, the skin will easily dissolve, turning into slime, in specimens left some time out of the water, before preservation. Development unknown.

In British seas this species has been found off the Irish west coast (" Helga "); the exact locality and depth unknown. It is known elsewhere from the Bay of Biscay, the Canaries, and the Mediterranean. Bathymetrical distribution ca. 5-400 m.

III. Family HOLOTHURIIDÆ

Tentacle ampullæ present. Gonads only on the left side of the dorsal mesentery. Respiratory trees usually connected with the alimentary canal through a rete mirabile. Stone canal not connected with the body wall. Cuvierian organs often present. Deposits usually tables and buttons or derivatives of pointed rods. No C-shaped bodies.

Mainly littoral forms, abundant in tropical seas, especially on coral reefs ; many species are eaten and form an important article of commerce (" trepang", " bêche de mer ").

In British seas only the genus *Holothuria* is known to occur, but another, *Gastrothuria* Perrier, is likely to occur there also, the only species known, *G. limbata* Perr., having been found in the Bay of Biscay, 564 m. (" Talisman ").¹

*Key to the genera of Holothuriidæ known from or likely
to occur in the British seas.*

Tentacle ampullæ small ; respiratory trees free (" Talisman "
Holoth., p. 469, Pl. XV. 1-14) . . . *Gastrothuria* Perr.

Tentacle ampullæ well developed ; respiratory trees connected with
the alimentary canal by a rete mirabile . . . 1. *Holothuria* Linn.

1. *Holothuria* Linnæus.

Mouth terminal ; usually 20 tentacles. No anal teeth. Tentacle ampullæ well developed ; respiratory trees connected with the alimentary canal by a rete mirabile. Cuvierian organs may be present.

Only one species, *Holoth. Forskali* D. Chiaje, known from the British seas. Several more species are found in the Mediterranean

¹ According to information received from Hj. Östergren, *Gastrothuria* is, however, very probably only a young *Stichopus regalis*.

and on the adjacent Atlantic coasts; three of these occur as far north as the French coasts, viz. *Holoth. Sanctori* Delle Chiaje (Syn. *H. farcimen* Selenka), *H. tubulosa* Gmelin, and *H. Poliï* D. Chiaje. There may perhaps be a slight possibility of finding these species also at the British south coasts, so that it may be desirable to give a key by which they may be distinguished. A detailed description of these species is given in Koehler's *Échinodermes, Faune de France*.¹

*Key to the species of Holothuria known from or possibly
occurring in the British seas.*

1. Deposits very scarce and rudimentary; no tables

1. *H. Forskali* D. Ch.

 Deposits numerous and well developed; tables and buttons 2
2. Disk of tables with smooth edge *H. Sanctori* D. Ch.
 Disk of tables with serrate edge 3
3. Buttons with smooth surface *H. Poliï* D. Ch.
 Buttons with rough surface *H. tubulosa* Gmel.

1. *Holothuria Forskali* Delle Chiaje.²

(“ The Nigger ” or “ Cotton-Spinner ”.) (Fig. 234.)

(Syn. *Holothuria nigra* Peach, Gray (Kinahan), Bell; *H. catanensis* Grube; *Stichopus Selenkæ* Barrois.)

Ventral side flattened, with numerous tube-feet, forming three or four longitudinal series, the middle one being often divided in two by a naked median space. Dorsal side with conical papillæ. Skin thick, soft. Cuvierian organs present. Deposits scarce and small, usually with 4 holes, sometimes with small tubercles (Fig. 235); in the tube-feet and papillæ elongate, irregularly branched rods, in the tentacles curved rods. Colour in life usually black on the dorsal side, the ventral side lighter, brownish or yellowish. The dorsal papillæ white at the tip, or they are (according to Norman) white with a black tip. Tentacles yellow. The general colour may also be, on the whole, lighter;

¹ Sluiter (“*Holothurien Sammlung d. Mus. Amsterdam*”, *Bijdr. tot de dierk.*, xvii., 1895) records *Holothuria glaberrima* Selenka from the North Sea (found in the stomach of a cod), and *Holoth. stellati* Marenzeller from the coast of England. The former species being elsewhere known only from the West Indian seas, the latter only from the Mediterranean, it is rather safe to say that there must be some mistake here, due either to incorrect labelling or to erroneous identification. There is no reason for further mentioning these species in the present work. As for *H. stellati*, which may possibly occur also outside the Mediterranean, a description will be found in Koehler's *Échinodermes, Faune de France*.

² The name is also written *Forskahli* or *Forskålii*.

it is even stated to be of "all shades, from sienna to rose-colour and delicate pink" (Peach). Grows to a considerable size, up to ca. 20 cm. length.

It is a shallow-water species, apparently apt to climb rock walls. When irritated it throws out its Cuvierian organs, which,

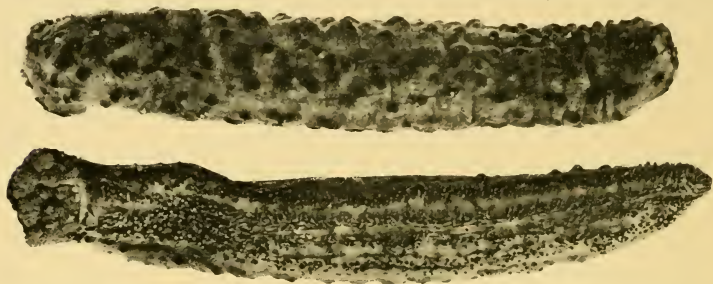


FIG. 234.—*Holothuria Forskali*; dorsal (upper figure) and ventral side (lower figure). Much reduced.

in the shape of long, white, sticky threads, dart through the water like arrows, entangling the objects they come into touch with. The larva is an Auricularia of very simple shape, and with a star-



FIG. 235.—Deposits of *Holothuria Forskali*. $\times 450$. (After Bell, *Catalogue Brit. Echinod.*)

shaped calcareous body in the posterior end. Breeding season in the summer months. The parasitic fish *Fierasfer* is found in this species, at least in the Mediterranean.

In British seas this species is fairly common along the south-west coast of England and the west coast of Ireland, from the Kenmare River to Donegal, from between tide-marks to a depth of ca. 50 m. Also recorded from the west coast of Scotland (Sleat Sound). It is elsewhere found along the Atlantic coasts of Europe and in the Mediterranean. The greatest depth from which it has been recorded is 68 m.

III. Order. DENDROCHIROTA Grube.

Tube-feet present; tentacles tree-shaped; tentacle ampullæ absent or small. Retractor muscles usually present. Respiratory trees present, sometimes connected with the alimentary canal through a rete mirabile. Stone canal hanging free in the body cavity. Mesentery of the posterior intestinal loop in left or right ventral interradius. Gonads on both sides of the dorsal

mesentery. Usually no Cuvierian organs. Deposits usually more or less irregular, fenestrated plates, sometimes tables.

The numerous forms of this order feed on plankton or detritus, which they catch by means of their very extensile tentacles. The plankton organisms or the detritus particles stick to the tentacles, which alternately bend down and are put into the mouth, where the food particles are sucked off.

The order is divided into three families or subfamilies, two of which are represented in the British seas.¹

*Key to the families of Dendrochirota found in the British
and the N.E. Atlantic seas.*

- Body usually cylindrical or fusiform, without a well defined ventral sole I. *Cucumariidæ*
 Body more or less flattened, with a sharply defined ventral sole
 II. *Psolidæ*

I. Family CUCUMARIIDÆ

Body more or less cylindrical or fusiform, not flattened, the ventral side not forming a thin-walled sole, sharply defined from the dorsal side. Tube-feet either confined to the radii or distributed all over the body. Mesentery of the posterior intestinal loop in the left ventral interradius.

This large family is divided into two subfamilies, which are thus distinguished :

- Tentacles 10 I. *Cucumariinæ*
 „ 15-30 II. *Phyllophorinæ*

I. Subfamily CUCUMARIINÆ

Ten tentacles, of which the ventral pair usually is smaller than the others, sometimes quite rudimentary or even absent.

Three genera of this subfamily are represented in British seas ; a fourth, the deep-sea form, *Sphærothuria* Ludwig (Syn. *Ypsilothuria* Perrier), is very likely to occur there also, the species *Sph. talismani* (Perr.) (Syn. *Ypsilothuria talismani* Perr.)² being known from the Bay of Biscay to Senegal, 1123-2330 m. ("Talisman") ; also taken in the North Atlantic by the "Ingolf."

¹ The third family, *Rhopalodinidæ*, contains only the peculiar genus *Rhopalodina*, from tropical W. Africa. R. Perrier refers to this family also the deep-sea form *Ypsilothuria*, which seems unacceptable.

² Another species, *Ypsilothuria attenuata* Perr., from off the Cape Verdes, 2330 m. ("Talisman"), is so incompletely known that it is scarcely recognisable. It is very probably identical with *Sph. talismani*.

Key to the genera of Cucumariinae known from or likely to occur in the British seas.

1. Tube-feet in more or less distinct series along the radii, not scattered all over the body 2
 Tube-feet all over the body, not in distinct series 3. *Thyone* Oken
2. Body covered with large, spinous scales; mouth and anus dorsal; a pair of lateral tentacles much larger than the others 3
 Body not covered with large, spinous scales; mouth and anus terminal; none of the lateral tentacles specially enlarged 1. *Cucumaria* Blv.
3. Scales thin, single-layered, with spine eccentric. Tube-feet not perforating the scales 2. *Echinocucumis* Sars
 Scales thick, consisting of several layers; spine nearly central. Tube-feet perforating the scales *Sphærothuria* Ludw.

1. *Cucumaria* Blainville.

(Syn. *Ocnus* Forbes; *Psolidus* Forbes; *Semperia* Lampert.)

Body cylindrical or with 5 longitudinal ridges, often curved dorsalwards, but then not strongly swollen in the middle. The skin usually thick, often quite stiff on account of the calcareous deposits; never spinous. The two ventral tentacles usually smaller than the others; none of the lateral tentacles larger than the others. Tube-feet in distinct, usually double series along the radii, more rarely also on the interradii.

The numerous species belonging to this genus will very probably be subdivided into various smaller genera or subgenera; but till now no acceptable subdivision has been made.

Seven species¹ are known from the British seas, but three more are likely to occur there also, namely, *Cucumaria arcuata* (Hérourard) (Syn. *Psolidium arcuatum* Hér.), 32° N., 17° W., 1700-1968 m. ("Princesse Alice"); *Cucumaria compressa* Perrier, found in the Bay of Biscay, 627 m. ("Talisman"); and *C. abyssorum* Théel,² found off the Azores ("Hirondelle"), and 45° 26' N.,

¹ *Cucumaria dissimilis* (Fleming) Forbes and *Cuc. Neillii* (Fleming) Forbes are entirely unidentifiable, and must be left out of consideration. Doubtless they are identical with some or other of the known Cucumariids from the British seas.

² Miss Deichmann has informed the author that in her opinion the Atlantic specimens referred to *Cucumaria abyssorum* are not really identical with the typical *abyssorum* from the S. Pacific; the species, which was also taken by the "Ingolf", will be described in Miss Deichmann's forthcoming report on the "Ingolf" Holothurians under the name of *Cucumaria Ingolfi* Deichm.

25° 45' W. ("Michael Sars"), 2870-3120 m.; the latter species has an almost cosmopolitan distribution, in depths of ca. 1650-4085 m. Several more littoral species are found in the Mediterranean and on the adjoining Atlantic coasts; but none of these are known to go so far north that there would seem to be any probability of their occurring within the British area. Descriptions of these species are found in Koehler's *Échinodermes, Faune de France*.

Key to the species of Cucumaria known from or likely to occur in the British seas.

1. Body more or less elongate, attenuating, anterior and posterior end usually curving upwards 2
 Body not elongate, attenuating, curving upwards 4
2. Middle part of the ventral side with tube-feet especially richly developed, forming a ventral sole. Deposits smooth plates, partly imbricating ("Monaco", lxvi., p. 117, Pl. VII. 1-4)
 C. arcuata (Hér.)
 Middle part of ventral side not like a sole 3
3. Body laterally compressed; large plates of the skin imbricating, the free part of the plate covered with triangular, flat tubercles ("Talisman" *Holoth.*, p. 505, Pls. XII. 7, XXI. 20-28)
 C. compressa Perr.
 Body not laterally compressed; large plates of the skin not distinctly imbricating, quite smooth 2. *C. elongata* Düb. and Kor.
4. Very large form; the skin thick, leathery, almost devoid of spicules. (Young specimens with large, irregular plates with small tubercles (Fig. 239, 2).) 1. *C. frondosa* (Gunn.)
 Small forms with numerous calcareous deposits 5
5. Deposits 4-armed, the ends of arms widened, thorny. Body fusiform; tube-feet completely retractile, sparse, in an alternating row along each radius ("Challenger" *Holoth.*, ii., p. 66, Pls. IV. 6, XVI. 6) *C. abyssorum* Théel
 Deposits not 4-armed 6
6. Calcareous deposits smooth 7
 " " tuberculate 8
7. Deposits large, fenestrated plates; no small star-shaped plates in the outer layer of the skin 3. *C. Hyndmani* Thomps.
 Deposits small, button-like, with 4 main holes and often one or a few at each end; small star-shaped bodies in the outer layer of the skin 4. *C. saxicola* Br. and Rob.
8. Small bodies in the outermost layer of the skin cup-shaped (Fig. 241, 2) 5. *C. Normani* Pace.
 Small bodies in the outermost layer of the skin irregular stars (Fig. 241, 1, 3) 9
9. Small forms scarcely exceeding 4 cm. length. Tube-feet scarce, in zigzag rows 6. *C. lactea* (Forbes)
 Larger forms, up to 15 cm. in length. Tube-feet in distinct double series 7. *C. Planci* v. Marenz.

1. *Cucumaria frondosa* (Gunnerus). (Fig. 236.)

(Syn. *Holothuria frondosa* Gunn.; *H. pentactes* O. Fr. Müll.; *H. fucicola* Forbes and Goodsir; (?) *Psolinus brevis* Forbes.)

Body cylindrical, somewhat attenuating towards the ends; tube-feet in larger specimens pluriserial, especially in the middle of the body, spreading to some degree also over the interradii on the dorsal side. They are completely retractile. Skin very thick, leathery, in larger specimens almost completely devoid of calcareous deposits; young specimens with a variable number of larger fenestrated plates with a few small tubercles (Fig. 239, 2). Colour dark brownish, somewhat lighter on the ventral side;



FIG. 236.—*Cucumaria frondosa*. Much reduced.

tentacles almost black. More lightly coloured specimens may occur, even such as are quite white. Grows to a very considerable size, up to ca. $\frac{1}{2}$ metre fully extended.

This large sea-cucumber, the largest of British and European species, is often found in great numbers at lower tide limit, especially among Laminarians, and, with its long extended bush-shaped tentacles, offers a very fine sight. Large specimens are difficult to preserve in extended condition; if preserved without narcotising they contract very strongly, pushing out their internal organs through the anus or through a rupture in the skin, usually in the anterior part of the body, where the skin is somewhat thinner.

Breeding season February-March, farther to the north (Greenland) in summer-time. The red, barrel-shaped larvæ may occur in such great numbers that the water looks quite red from

them. Younger specimens are eaten by fishes (*e.g.* haddock, plaice).

In British seas this species is found at the north coasts of Scotland, from north of Firth of Forth (Montrose) to the Clyde, and at the Shetland and Orkney Islands, in places in immense numbers. (Are called "Puddings" by the fishermen.) Bell (*Catalogue*) also records it from Plymouth, but this is certainly due to some error (as also the statement of its occurring off Portugal is no doubt erroneous). It is elsewhere widely distributed over the Arctic Region, but is not known south of Hardanger on the Scandinavian coasts. On the N. American coasts it goes as far south as Massachusetts. Also recorded from off Florida, but this again is no doubt due to an error. Some related forms are known from the N. Pacific. Bathymetrical distribution, 0-ca. 200 m.

2. *Cucumaria elongata* Düben and Koren. (Fig. 237, 2.)

(Syn. *Cucumaria pentactes* Forbes ; (?) *C. fusiformis* Forbes and Goodsir.)

The body very elongate, attenuating towards both ends, especially the posterior end being long and thin. Usually both



FIG. 237.—1. *Cucumaria lactea*. 2. *Cuc. elongata*. 3. *Cuc. Hyndmani*. *C. elongata* with the tentacles retracted. All nat. size. (From *Danmark's Fauna*.)

ends are curved upwards, the body being thus bent like a U. Tentacles small. Tube-feet in 5 distinct double rows, towards the ends of the body more in zigzag rows; they are not quite retractile. Calcareous deposits of three different kinds (Fig. 238). In the deeper parts of the skin is found a rather close layer of larger, somewhat irregular, smooth plates with numerous small

holes (Fig. 238, 1); above this layer lie more scattered some smaller, rounded plates with few holes (Fig. 238, 2), and in the superficial layer again rather numerous small cup-shaped bodies (Fig. 238, 3). Transitional forms

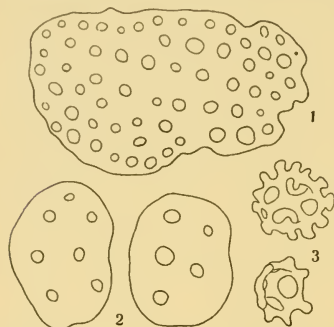


FIG. 238.—Calcareous deposits of *Cucumaria elongata*. 1, $\times 50$; 2-3, $\times 145$. (From *Danmark's Fauna*.)

between the two kinds of plates are found. Colour usually dark brownish, which keeps well on preservation in alcohol. Grows to a length of ca. 15 cm.

It lives on muddy bottom, where it lies buried with only the anterior and posterior ends above the surface; it has been observed in aquaria to lie for long periods with the anterior end wholly concealed in the ground, which might indicate that it does not exclusively subsist on plankton and detritus, but may fill its ali-

mentary canal directly with bottom material. Development unknown.

In British seas this species is known from Plymouth, round the west coasts to the Shetlands, and to Northumberland and Durham on the east coast, in depths of ca. 4-65 m. It is elsewhere distributed from the Trondhjem Fjord to the Sound in the Scandinavian seas, and to Heligoland in the North Sea; further, to the Mediterranean in the south. It is not known from Greenland or the east coast of N. America.

3. *Cucumaria Hyndmani* Thompson. (Fig. 237, 3.)

Body short, rather barrel-shaped, slightly attenuating posteriorly, slightly curved. Skin thick, smooth, leathery. Tube-feet almost completely retractile, in distinct double rows. Deposits (Fig. 239, 1) large, smooth, fenestrate plates, lying very close and, when the animal is contracted, imbricating like scales. Colour whitish-grey or faintly reddish. Grows to a length of ca. 5 cm.

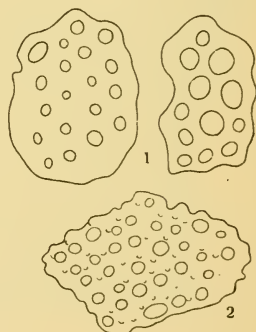


FIG. 239.—Calcareous deposits of *Cucumaria Hyndmani* (1) and *Cuc. frondosa*, young (2). 1, $\times 50$; 2, $\times 80$. (From *Danmark's Fauna*.)

It lives on hard bottom, especially shell bottom, and covers itself with shells and pebbles, being thus very well concealed and easily overlooked among the contents of a dredge. Development unknown.

In British seas this species is known from the south and west coasts to the Shetland Islands, and to St. Andrews on the east coast. Also recorded from the Rockall Bank ("Porcupine"). It is usually found in rather deep water. It is elsewhere distributed from the Trondhjem Fjord to the Mediterranean; not known from Greenland or the east coast of N. America. Bathymetrical distribution ca. 20-1150 m.

4. *Cucumaria saxicola* Brady and Robertson.¹ (Fig. 240.)

(Syn. *Cucumaria Montagu* Flem., partim; *Colochirus Lacazei* Hérourard.)

Body almost cylindrical; skin rather delicate, relatively thin, the surface smooth. Tube-feet in distinct double rows on the ventral side; on the dorsal side more in zigzag rows, and they are here reduced to papillæ, except at the anterior end. Gonadial tubes ca. 10-60, large, club-shaped. Deposits (Fig. 240) small, rather button-like, with 4 main holes and often one or a few at each end; small scattered star-shaped bodies in the outer layer of the skin. Spicules of tube-feet rods with usually a single series of holes. Colour white, tentacles dark; when exposed to light it develops black pigment, also on the body. Grows to a length of ca. 15 cm.

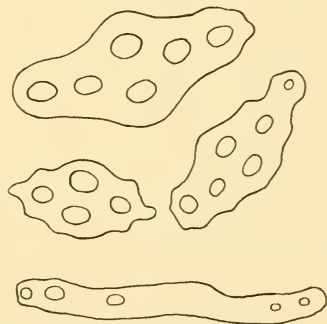


FIG. 240.—Deposits of *Cucumaria saxicola* from the skin and the tube-feet (the lowermost figure). $\times 180$.

Mainly a littoral form, especially in rock crevices or under stones. Spawning period about May.

¹ With regard to the very intricate synonymy of the species *Cucumaria saxicola* and *Normani*, see especially J. H. Orton, "On some Plymouth Holothurians", *Journ. Mar. Biol. Assoc.*, x., 1914, p. 225. The present author agrees with the English authors, who have treated this question more recently, that the old name *Montagu* must be abandoned, the species originally meant therewith being entirely unidentifiable. Also the name *Lefevrei* Barrois seems unacceptable on account of the contradiction between the description and the figures.

In British seas this species appears to be common on the south coast of England (Plymouth), and on the west coast of Ireland, occurring from the shore down to ca. 45 m. Elsewhere known from the Atlantic coasts of France and from the Azores, down to a depth of 130 m.

5. *Cucumaria Normani* Pace. (Fig. 241, 2.)

(Syn. *Cucumaria Montaguï* Flem., partim; *C. Lefevrei* Barrois; *Semperia Lefebvrei* Hérourard.)

Body almost cylindrical, skin tough, leathery, surface wrinkled. Tube-feet in distinct double rows; there may also be some in the interradii; those of the dorsal side not transformed into papillæ. Gonadial tubes very numerous, ca. 500 or more, small, cylindrical. Deposits (Fig. 241, 2) with 4 holes and on the upper side ca. 12 very prominent nodules. Surface spicules cup-shaped, forming a continuous layer. Spicules of tube-feet with 2 or more parallel rows of holes, or larger, irregular plates. Colour dirty brownish-white, becoming black when exposed to light. Grows to a length of ca. 15 cm.

Mainly a littoral form, like the preceding species. Spawning period about March.

In British seas this species is known from the south coast (Plymouth) and the west coast of Ireland; it appears to be less common than the preceding species. Known elsewhere only from the Atlantic coasts of France. It is not known from more than 20 m. depth.¹

6. *Cucumaria lactea* (Forbes). (Figs. 237, 1; 241, 3.)

(Syn. *Ocnus lacteus* Forbes; *O. brunneus* Forbes²; *Cuc. mosterensis* Grieg.)

Body cylindrical. Skin very thick, leathery, smooth. Tube-feet scarce, in zig-zag rows; they are not quite retractile. The

¹ A variety *corogna* Hérourard (from the harbour of Coruña) differs from the type in its colour, greyish, with the tube-feet yellowish-red. The deposits are slightly smaller than in the type. As the single specimen known was covered with Nematods, boring into the base of the tube-feet, it seems very doubtful whether the characters presented by this specimen are anything but pathological, and the value of this variety is very problematic.

² The species described in Koehler's *Échinodermes, Faune de France*, p. 164, under the name of *Cucumaria brunnea* (Forbes), is evidently not identical with *C. lactea*, but apparently represents a separate species. Koehler records it as occurring both in the Mediterranean and on the Channel

very numerous deposits (Fig. 241, 3) are covered with nodules; they have usually only 4 holes, but larger, more irregular plates also occur. In the superficial layer small, irregular, star-shaped "cups" occur. Colour white or brownish. Does not grow to a larger size than ca. 4 cm.

It lives on stony or shell bottom or among calcareous algæ, from tide marks down to ca. 100 m. Development unknown.

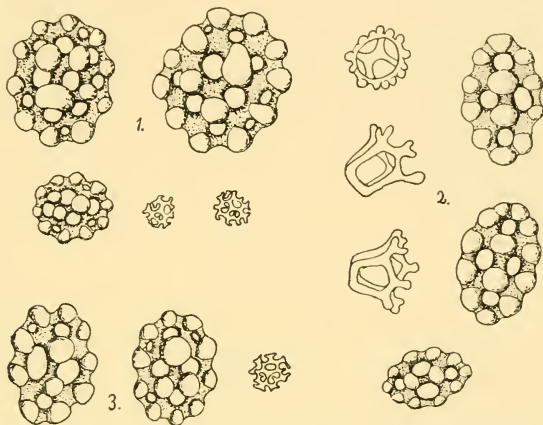


FIG. 241.—Deposits of *Cucumaria Planci* (1), *Cuc. Normani* (2), and *Cuc. lactea* (3). $\times 190$.

But it has been observed to propagate by self-division. It is eaten by various fishes—cod, haddock, plaice.

In British seas this species is known from the south and west coasts to the Shetland Islands, and on the east coast down to Northumberland and Durham. It is known from Trondhjem-fjord to Kattegat in Scandinavian seas; to the south it is not known south of Brittany.

7. *Cucumaria Planci* v. Marenzeller. (Fig. 241, 1.)

(Syn. *Cucumaria doliolum* Lamk., partim.)

Body cylindrical or somewhat prismatic. Skin thick and leathery, but smooth. Tube-feet in distinct double series in all

coasts; but a specimen sent to the author by Koehler proved to agree completely with *C. lactea* except in the brown colour; it came from Plymouth. Other brown specimens from the north European seas examined by the author likewise agreed with *lactea*, except in the colour. It seems evident that Forbes's *Ocnus brunneus* is nothing but a brown colour variety of *lactea*, while the form described by Koehler under the name *C. brunnea* is a different species, perhaps confined to the Mediterranean.

five ambulacra, retractile. Deposits very numerous, button-like, covered with nodules ; they are usually somewhat larger and with more holes than in those of *C. lactea*, which they otherwise resemble very much, as also the small, irregular " cups " in the outermost layer of the skin are identical in the two species. Colour brownish, often with irregular darker spots. Grows to a size of ca. 15 cm. length, by a thickness of 3.3-5 cm.

Development direct, without a pelagic larval stage. It prefers a muddy bottom, in depths of a few metres. In the Mediterranean the fishermen use it (the inner layer of the skin) for bait.

In British seas this species has been recorded from the south coast to the Clyde. It is elsewhere known from the coast of Portugal, off Senegal, and the Mediterranean. Bathymetrical distribution ca. 15-175 m.

2. *Echinocucumis* M. Sars.

Body thick, ovoid, attenuating at both ends, which curve upwards, the mouth and anus being thus dorsal. The body wall is thin, but stiff on account of the large, scale-like deposits, which carry a rather long spire, making the body spinous. Tentacles unequal, a lateral pair much larger than the others ; the ventral tentacles small, rudimentary. Tube-feet scarce, very thin, not perforating the scales, but issuing between them, at most forming a notch in the edge of the scales. These latter are thin, single-layered ; the spire eccentric. Small forms, mainly from deeper water.

Only one species known from the British and N.E. Atlantic seas.

1. *Echinocucumis hispida* (Barrett). (Fig. 242.)

(Syn. *Eupyrus hispidus* Barrett ; *Cucumaria hispida* Bell ; *Echinocucumis typica* M. Sars ; *Ypsilothuria talismani* Perr., *pro parte*.)

Anterior and posterior end forming long, slender tubes, which cannot be completely retracted. Tube-feet in the ventral radii in zig-zag rows ; in the dorsal radii they are found only at the anterior and posterior end, not in the middle of the body. They are rather difficult to see, being scarcely larger than the spines. Scales large, more than 1 mm., smooth, perforated by rather large holes, becoming smaller towards the margin (Fig. 243). Most of the plates carry an eccentric spire, composed of 4 slightly spiny rods. Towards both ends the spire disappears

and the plates are reduced in size. Colour whitish; the skin transparent, the internal organs being discernible through the skin. Does not grow to a larger size than ca. 3 cm. length.

The variety *abyssalis* Koehler, from the Bay of Biscay, 650 m. ("Caudan"), differs from the typical form in the spire being much shorter, conical. (Cf. *Échinod.* "Caudan", Pl. II. 22.)

It lives on muddy bottom, probably buried in the mud, with only the mouth and anal prolongation above the ground surface. Development unknown.

In British seas this species is known only from off the Irish west coast, from ca. 750-1430 m. ("Porcupine", "Helga"). It is also recorded from a depth of 2172 m. off S.W. Ireland ("Porcupine"), but this is more probably *Sphærothuria talismani*. The species is elsewhere distributed from North Cape to the Bay of Biscay. The statements of its occurrence in the West Indies and off South Africa are probably due to confusion with

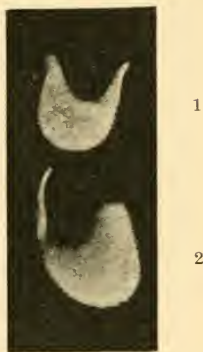


FIG. 242.—1. *Echinocucumis hispida*. 2. *Thyone raphanus*. Nat. size. (From *Danmark's Fauna*.)

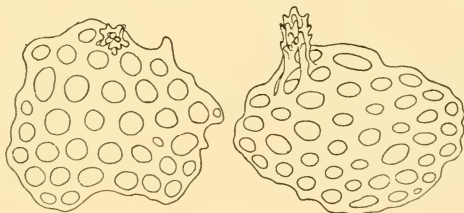


FIG. 243.—Calcareous deposits of *Echinocucumis hispida*. $\times 50$ (From *Danmark's Fauna*.)

Sph. talismani (or other species?). The bathymetrical distribution is ca. 50-ca. 1400 m.; it cannot be said exactly to how great depths it is known to descend, because there has evidently been a great deal of confusion between this species and *Sphærothuria talismani*; the specimens from the greater depths may be expected to be, mostly at least, *Sph. talismani*.

3. *Thyone* Oken.

Body usually thick, ovoid, more or less attenuating, especially towards the posterior end. Body wall thin, soft. None of the lateral tentacles enlarged. Tube-feet spread all over the body,

the serial arrangement usually indistinct (except in young specimens, where they are restricted to the radii, forming double series). Radialia in the calcareous ring usually with a double posterior prolongation (Fig. 211, 1). Calcareous deposits of various forms, but not large, spinous scales, sometimes absent; often 5 prominent spicules round the anal opening ("anal teeth").

Three species of this genus have been recorded from the British seas, but two more are rather likely to occur there also, namely *Thyone roscovita* Hérourard, known from the French coasts, from the Channel to Arcachon (littoral to 40 m.); and *Th. serrifera* Östergren, only known from the Trondhjemsfjord, 200-500 m.

*Key to the species of Thyone known from or likely
to occur in the British seas.*

1. Calcareous deposits developed in the whole of the skin 2
 Calcareous deposits entirely absent from the skin or developed
 only in the posterior end of the body 4
2. Deposits with a spire, composed of 2 rods
 1. *Th. fusus* (O. F. Müll.)
 Deposits without a spire 3
3. Deposits with smooth holes; body with a long, thin posterior
 prolongation, like a tail 2. *Th. raphanus* Düb. and Kor.
 Deposits with serrate holes (Fig. 245, 2); no tail-like posterior
 prolongation of body *Th. serrifera* Östergren.
4. Deposits entirely absent, except the terminal disk of the tube-
 feet and the anal teeth; also the 10 tube-feet surrounding
 the anal opening contain some simple rods. Skin thick, not
 transparent, rosy grey *Th. roscovita* Hér.
 Deposits present in the posterior part of body; skin thin, trans-
 parent, rosy 3. *Th. inermis* Heller

1. *Thyone fusus* (O. Fr. Müller). (Fig. 244.)

(Syn. *Thyone papillosa* (Müll.) Forbes; *Th. flexus* Hodge;
Th. subvillosa Hérourard; *Th. gadeana* Perrier.)

Body attenuating towards both ends, but the posterior end not produced into a long, tail-like prolongation. The tube-feet may show a more or less distinct serial arrangement. Deposits (Fig. 244) not very numerous, small, smooth tables with usually 4 holes and a spire formed by 2 rods which unite at their upper end, where they are provided with a few thorns. Sometimes the disk may be more irregular, with some outer holes. The tables are found also in the tube-feet. Colour in life whitish or rosy. Grows to a length of ca. 20 cm.

It is usually found on shell bottom, and covers itself with fragments of shells, being therefore easily overlooked in the contents of the dredge. On account of the delicacy of its skin, it often ruptures through the contraction of the animal on capture, the pharynx with the characteristic calcareous ring thus hanging out. Development unknown.

In British seas this species appears to occur all round the coasts from Plymouth to the Shetlands, and down to Cullercoats on the east coast. Also known from the Rockall Bank. It is elsewhere distributed from the Trondhjem Fjord to Madeira and the Mediterranean, in depths of ca. 10-615 m.

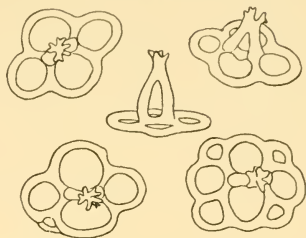


FIG. 244. — Calcareous deposits of *Thyone fusus*. $\times 200$. (From *Danmark's Fauna*.)

2. *Thyone raphanus* Düben and Koren. (Fig. 242, 2.)

(Syn. *Thyone Poucheti* Barrois.)

Body thick, ovoid, attenuating posteriorly into a long, thin, tail-like prolongation, the animal thus resembling to some degree a radish. Usually it is bent like a U. Tube-feet less numerous on the dorsal side and wholly absent in the posterior part of the caudal prolongation. Deposits (Fig. 245, 1) rather large, smooth, or more or less tuberculate, fenestrated plates, lying so close as to be partly imbricating, like scales. Colour in life yellowish or brownish, fading in alcohol. Attains a size up to 6 cm. length.

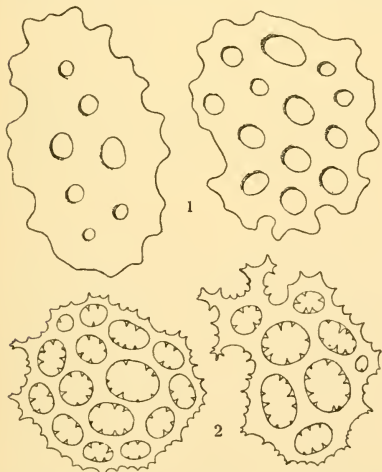


FIG. 245. — Calcareous deposits of *Thyone raphanus* (1) and *Th. serrifera* (2). $\times 145$. (From *Danmark's Fauna*.)

It lives on sandy or muddy bottom, buried in the ground, with only the tail-end protruding above the surface. It thus seems that it is not a plankton-feeder, as are usually the *Dendrochirotes*, but directly ingests the bottom

material. Development unknown; the breeding season appears to be in winter.

In British seas this species appears to occur all round the coasts from Plymouth to the Shetland Islands, and on the east coast down to Northumberland. It is elsewhere distributed from the Trondhjem Fjord to the Mediterranean. Bathymetrical distribution ca. 10-1050 m.

3. *Thyone inermis* Heller. (Fig. 246.)

(Syn. *Thyone aurantiaca* Costa; *Th. elegans* Norman.)

Body fusiform, attenuated towards the ends, but the posterior end not drawn out into a long, tail-like prolongation. Body wall thin, very delicate, transparent, devoid of calcareous deposits, except in the posterior end, where small, more or less regular disks, with a spire composed of 2 rods, are found. Tube-feet

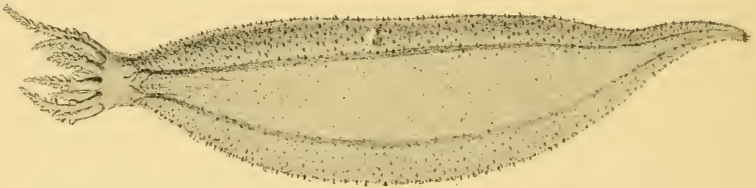


FIG. 246.—*Thyone inermis*. Slightly reduced. (After Hérourard, *Recherches s. l. Holoth. côte de France.*)

without spicules, only the terminal disk well developed. Tentacles “completely clothed in a scaly investiture of irregular-shaped cribriform calcareous plates.”¹ Colour in life rosy. Grows to a length of 15 cm.

Biology and development unknown.

In British seas this species has only been found at the Shetland Islands (Norman); but it cannot be doubted that it will prove to occur also at least along the west coasts. It is elsewhere known from the Bay of Biscay, the Azores, and the Mediterranean. Bathymetrical distribution ca. 30-180 m.

II. Subfamily PHYLLOPHORINÆ

Tentacles 15-30, larger and smaller, so arranged that a pair of larger tentacles are found in each interradius, one or more

¹ Thus stated by Norman in his description of *Thyone elegans*, while nothing is said about it in other descriptions of *Th. inermis*. The author has not himself had the opportunity of examining this species.

small ones in each radius; the latter are placed nearer the mouth, there being thus two circles of tentacles.

Two genera of this subfamily are known from the British seas; a third, *Phyllophorus*, with the species *Ph. urna* Grube, is a littoral form, known only from the Mediterranean. There may, perhaps, be some possibility of finding this form in the adjoining regions of the Atlantic, and it may, in any case, be desirable to include it in the key to the genera of the *Phyllophorinæ*, the more so as the genus *Thyonidium* has, apparently erroneously, been united with *Phyllophorus*.¹

Key to the genera of Phyllophorinæ known from or possibly occurring in the British seas.

1. Tube-feet confined to the radii 1. *Pseudocucumis* Ludw.
 ,, spread all over the body 2
2. Five pairs of large tentacles in the outer circle and 5 pairs of small ones in the inner circle; calcareous ring without posterior prolongations 2. *Thyonidium* Düb. and Kor.
 Outer circle of large tentacles with more than 10 (12-15), not in pairs. Inner circle with usually only 5 single small tentacles; calcareous ring with posterior prolongations

Phyllophorus ² Grube

1. *Pseudocucumis* Ludwig.

Tentacles 20 (18), the 10 (8) smaller alternating with the larger or forming an inner circle. Tube-feet confined to the ambulacra, only rarely a few tube-feet may be found scattered in the interradii in the middle of the body. Both radialia and interradialia of the calcareous ring may have posterior prolongations.

One species known from the British seas; another species, *Ps. Marioni* (v. Marenzeller) (Syn. *Cucumaria Marioni* v. Marenz.) is known from the Mediterranean and may possibly be expected to occur also in the adjoining Atlantic region.³

¹ Miss Deichmann has recently undertaken a revision of *Phyllophorus* and *Thyonidium*, and has kindly informed the author of her results and allowed him to include them in the present work. The detailed report on these studies will appear in the forthcoming report on the "Ingolf" Holothurians.

² For a description of *Phyllophorus urna* see Koehler, *Échinodermes, Faune de France*, p. 169. It may be recalled here that this species is viviparous.

³ For a description of this species see Koehler, *Échinodermes, Faune de France*, p. 169.

Key to the species of Pseudocucumis known from or possibly occurring in the British seas.

Deposits tables, with the spire formed by 4 columns

1. *Ps. mixta* Östergren.

Deposits tables, with the spire formed by 2 columns

Ps. marioni Marenz.

1. *Pseudocucumis mixta* Östergren. (Fig. 247, 1-2.)

(Syn. *Pseudocucumis Cuénoti* Koehler and Vaney.)

Body elongate, cylindric, attenuated towards the ends. In younger specimens the tube-feet form regular double series; in larger specimens they are more crowded in the middle part of the body, forming up to 6 double series, only a narrow naked part being left in the interradii. Both radialia and interradia in the calcareous ring with a long, articulate, posterior prolongation,

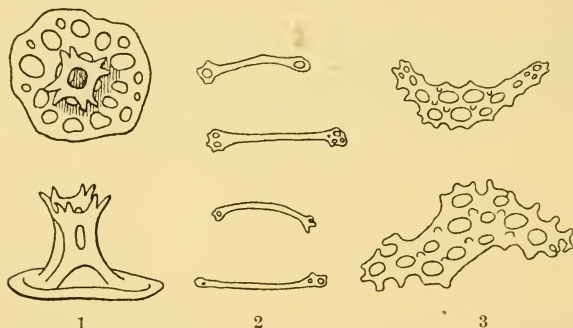


FIG. 247.—Calcareous deposits from the body wall (1) and the tentacles (2) of *Pseudocucumis mixta*; deposits from the tentacles of *Thyonidium pellucidum* (3). $\times 100$. (1. After Östergren; from *Danmark's Fauna*.)

bifurcating at the end. Calcareous deposits (Fig. 247, 1) very numerous, lying crowded in the skin; they are tables with a large disk perforated by many holes and with smooth edge; the spire composed of 4 columns. Tentacles with numerous slender rods, slightly widened at the ends (Fig. 247, 2). Colour yellowish-violet; the tentacles often darker. Grows to a size of at least 20 cm., probably more.

It lives on a stony, muddy bottom, probably also on sandy bottom. May be found thrown up on the beach after storms. Development unknown.

In British seas this species has been found off the Irish west coast in depths of 32-67 m. No doubt it will be found to have a wider distribution along the British coasts. It is elsewhere

known from Norway (Molde), the Faroe Islands, and Atlantic coasts of France. Bathymetrical distribution ca. 30-200 m.

2. *Thyonidium* Düben and Koren.

(Syn. *Orcula* Troschel.)

Tentacles 20, arranged in two circles, the outer consisting of 5 pairs of larger, the inner circle of 5 pairs of smaller, tentacles. Tube-feet spread all over the body, except in the young specimens.¹ Calcareous ring without long, articulated, posterior prolongations. Deposits scarce (except in young) or absent; they have the shape of tables.

Two species known from the British (and European) seas.

Key to the British (and European) species of Thyonidium.

Tentacles of each pair in the inner circle placed close together. Body wall thin, transparent. Tube-feet large, relatively few

1. *Th. pellucidum* (Flem.)

Tentacles of each pair of inner circle distinctly separate. Body wall thick, not transparent. Tube-feet very numerous, fine

2. *Th. commune* (Forbes).

1. *Thyonidium pellucidum* (Fleming). (Fig. 248.)

(Syn. *Thyonidium hyalinum* Forbes; *Phyllophorus pellucidus* (Flem.), Ludwig, Bell, etc.; *Orcula Barthii* Troschel.)

Body fusiform, scarcely attenuating towards the ends. The tentacles of each pair in the inner circle placed close together, so that when they are contracted they appear much as if they are united at the base. Body wall thin, hyaline, rather transparent. Tube-feet large, relatively few. Deposits tables with a low spire and rather large disk with serrate edge (Fig. 249); in the tentacles larger, fenestrated plates (Fig. 247, 3). They are fairly numerous in young specimens, but they disappear with age and are then found only in the



FIG. 248. — *Thyonidium pellucidum*, with tentacles retracted. Slightly reduced in size. (From *Danmark's Fauna*.)

¹ Such young specimens, with the tube-feet confined to the ambulacra, must be distinguished from *Pseudocucumis* by their calcareous deposits and the calcareous ring.

introvert and the posterior end of the body. Calcareous ring with radials and interradials distinct even in large specimens. Colour in life usually reddish. Grows to a length of ca. 12 cms. (or more ?).

It lives especially on a sandy, muddy bottom, and usually covers itself with shell fragments, etc. It is much eaten by fishes,



FIG. 249.—Deposits from body wall of *Thyonidium pellucidum*.
× 145. (From *Danmark's Fauna*.)

1. From above. 2. Half side view. 3. Side view.

especially the cod. Often the fishes bite off the tentacles or the whole anterior end. Development unknown.

In British seas this species is known from S.W. Ireland to the Shetland Islands, and down to the Northumberland coast on the east side. Elsewhere distributed from the Arctic seas to the Channel, and from Greenland to Florida. Bathymetrical distribution ca. 10-380 m.

2. *Thyonidium commune* (Forbes). (Fig. 250.)

(Syn. *Thyonidium*, *Phyllophorus Drummondii* (Thompson)¹;
Thyonidium Dübeni Norman; *Cucumaria communis* Forbes;
Thyone Portlocki Forbes.)

Body rather elongate, cylindrical, tapering towards the ends. Tentacles of each pair of the inner circle distinctly separated. Body wall thick, not transparent even in small specimens. Tube-feet very fine and very numerous, more or less distinctly arranged in series. Deposits completely absent, except in the introvert; they are small, delicate tables with a high, slender spire (Fig. 250), which may sometimes be reduced, the disk alone being left; in the tentacles large fenestrated plates. Calcareous ring in larger specimens large, shapeless, while in young specimens the radials and interradials are distinct, as in *Th. pellucidum*.

¹ The name *Drummondii* Thompson ought not to be used, as it is quite impossible to say to which species the original description really refers. The form described by Forbes under that name is certainly not a *Thyonidium*; the arrangement of the tube-feet, as shown by his figure (p. 223), rather suggests *Pseudocucumis*.

Colour whitish, the tentacles usually darker, of a violet tint. Grows to a length of ca. 20 cm.

Biology probably as in the preceding species. Development unknown.

In British seas this species is recorded from Cornwall, the Irish Sea and the Scottish west coast, the Shetland Islands, Firth of Forth, and from the Northumberland coast. Very probably it really occurs along these coasts, but as there has evidently been rather much confusion of the two *Thyonidium* species and *Pseudocucumis mixta*, the exact localities given are scarcely quite reliable. The species has about the same horizontal and vertical distribution as the preceding species, as far as the identifications are to be relied upon.

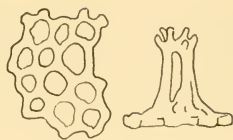


FIG. 250. — Deposits from introvert of *Thyonidium commune*. $\times 250$. (From an unpublished drawing by Miss Deichmann.)

II. Family PSOLIDÆ¹

Body usually flattened; the ventral side forms a thin-walled sole, sharply limited against the dorsal side, which is covered with large, imbricating scales. Mouth and anus dorsal. Tentacles 10-15. Tube-feet especially developed along the edge of the ventral sole (viz. in the ventro-lateral radii), forming a continuous circle round the edge, while they are often absent in the mid-ventral radius. On the dorsal side the tube-feet may be present or absent. Mesentery of the posterior intestinal loop in the right ventral interradius.

Only one genus known from the British and N.E. Atlantic seas. Another genus, *Psolidium* Ludwig, has been recorded from off Madeira ("Princesse Alice"), namely the species *Ps. arcuatum* Hérouard. It is, however, evident that this species is no true *Psolidium*, but rather a *Cucumaria*, and it is mentioned under that genus (p. 396). The true *Psolidium* has the same general appearance as a *Psolus*, but it differs from the latter in having tube-feet also on the dorsal side (perforating the scales), while in *Psolus* tube-feet are present, outside the ventral sole, only on the introvert and, in the shape of small papillæ, around the anal opening.

¹ As stated in the Danish work (*Echinodermes, Danmark's Fauna*, p. 239), the author is greatly indebted to Dr. Hj. Östergren, Gothenburg, for much very important information regarding the characters of the species of *Psolus*.

1. *Psolus* Oken.(Syn. *Cuvieria* Peron.)

Tentacles 10. Tube-feet developed almost exclusively on the ventral sole; outside the ventral sole tube-feet are found only on the soft-skinned introvert and, in the shape of small papillæ, around the anal opening, while the whole dorsal side is otherwise devoid of tube-feet. Body outside the ventral sole covered with thick, mostly imbricating scales, which usually carry small, rounded grains on their surface. In the ventral sole only scattered microscopical plates are found.

The Psolids live attached to stones, shells, and other hard objects, their ventral sole acting as a powerful sucking disk. In *Psolus phantapus* this, however, holds good only for young specimens. The larger specimens of this species live free in the bottom, with only the anterior and posterior ends protruding above the ground.

Three species of this genus are known from the British seas, but three, possibly four more may be expected to occur there also, namely, *Psolus nummularis* R. Perrier, found at 31° 31' N., 12° 47' W., 1050 m. ("Talisman"); *Ps. Pourtalesii* Théel, found south of Iceland ("Ingolf"),¹ known elsewhere from the West Indies ("Blake"); and *Ps. tessellatus* Koehler, Bay of Biscay, 1700 m. ("Caudan"; only one specimen known). A fourth species, *Ps. operculatus* Pourtalès, has been recorded (Ludwig) from off Spitzbergen; if the identification be correct, this species, which is elsewhere known from off Florida, must be widely distributed over the North Atlantic.

*Key to the species of Psolus known from or likely
to occur in the British seas.*²

1. Body not flattened; posterior end produced into a long, tail-like prolongation; mid-ventral radius of the sole with tube-feet throughout its whole length. Scales rather small; no large oral valves 1. *Ps. phantapus* (Strsf.)
- Body usually flattened, the posterior end not produced into a tail-like prolongation; mid-ventral radius of sole with tube-feet only at the ends or entirely without tube-feet. Scales rather large 2

¹ According to information by Miss Deichmann; not yet published.

² The fact that young specimens, especially of *Ps. phantapus*, are rather unlike the adult makes it necessary to let them appear twice in the key, which is thus rendered more complicated.

- | | |
|--|---------------------------------|
| 2. Mouth opening ¹ surrounded by 5 or 10 larger, valve-like plates | 3 |
| Mouth opening surrounded by a variable number of smaller, usually not valve-like plates | 6 |
| 3. Mouth opening surrounded by 10 valve-like plates, regularly alternating large and small. (Koehler, <i>Échinod.</i> "Caudan", p. 119, Pl. XXVII. 12-14) | <i>Ps. tessellatus</i> Koehler |
| Mouth opening surrounded by 5 (rarely more) ² large, valve-like plates | 4 |
| 4. Inside the point of the valves some small plates are found | 2. <i>Ps. squamatus</i> , young |
| No small plates inside the point of the valves | 5 |
| 5. Scales smooth, about 5 between oral and anal opening; deposits of sole scarce, only flat plates with small knobs; no cups | 3. <i>Ps. valvatus</i> Östergr. |
| Scales granulated, about 10 between oral and anal opening. Deposits of sole numerous, both plates and cups (Théel, "Blake" <i>Holoth.</i> , p. 12, Fig. 6) | <i>Ps. operculatus</i> Pourt. |
| 6. Deposits of ventral sole cups and larger, complicated bodies (Fig. 252) | 1. <i>Ps. phantapus</i> , young |
| Deposits of ventral sole only small, flat plates (Fig. 254) | 7 |
| 7. On the dorsal side, between oral and anal opening, small scales intermingled with the large ones. Very small form ("Talisman" <i>Holoth.</i> , p. 512) | <i>Ps. nummularis</i> Perr. |
| Large scales between mouth and anus not intermingled with small ones | 8 |
| 8. Shape broad, oval; scales very large, 8-10 in a series between mouth and anal opening | 2. <i>Ps. squamatus</i> Koren |
| Shape elongate, narrow; scales smaller, ca. 20-25 in a series between mouth and anal opening (Théel, "Blake" <i>Holoth.</i> , p. 14, Fig. 6) | <i>Ps. Pourtalesii</i> Théel |

1. *Psolus phantapus* (Strussenfelt). (Fig. 251.)

Body rather high and vaulted; anterior and posterior end prominent, especially the posterior end produced into a long, conical, tail-like prolongation. Body wall thick, scales rather small, granulated, in large specimens hardly discernible without special preparation. Ventral sole rather small, rectangular, narrower than the body. Tube-feet in the mid-radius in a complete series in the whole length of the sole. The two dorsal retractor muscles attached to the body wall in the

¹ For the sake of simplicity the term "mouth opening" is used here; in reality it is not the mouth opening but the opening through which the tentacles and—in larger specimens—the whole fore-end (the "introvert") are evaginated.

² Some of the valves may be subdivided into two halves.

interradii.¹ Deposits of the ventral sole of two sorts: small cups and larger, spherical or oval bodies, of a rather complicated structure (Fig. 252). Grains on the scales globular, ca. 0.3 mm. in diameter. Colour yellowish-brown, larger specimens often nearly black. Tentacles orange. Grows to a length of ca. 15 cm.

Young specimens differ, according to size, more or less conspicuously from the adult in their general appearance. They may be very flattened, and the "tail", which is not yet very

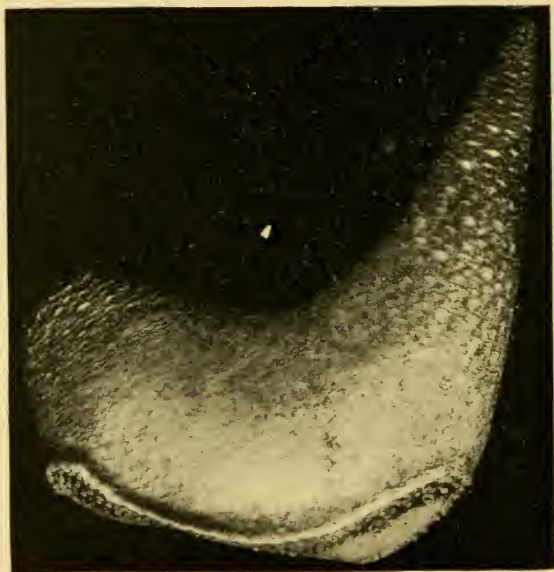


FIG. 251.—*Psolus phantapus*; in side view. The tentacles and the fore-end retracted. On the under side the ventral sole is seen. Nat. size. (From *Danmark's Fauna*.)

conspicuous, may be quite retracted. The ventral sole is relatively much broader than in the adult, and the tube-feet of the mid-radius not yet developed. Such specimens, in fact, look very much like *Ps. squamatus*. They may, however, be distinguished with full certainty from the latter species by the deposits of the ventral sole, and by the character of the dorsal retractor muscles, as stated above. Also the scales of the dorsal side are already in specimens of 5-10 mm. length distinctly,

¹ This character of the retractor muscles affords a very reliable distinction between this species and *Ps. squamatus* in the young stages, where they are rather alike.

though sparsely, granulated, which they are not yet in such young *squamatus*. The "tail" is, even when completely retracted, discernible by its scales forming a larger number of rings around the anal opening, varying according to the size of the specimen (at 15 mm. length ca. 6 rings), but always distinctly larger than in specimens of a corresponding size of the other species.

This Holothurian is often eaten by fishes, especially the cod. Also sea-stars, especially large *Solasters*, devour it. The *larva* is barrel-shaped, red. Breeding season from March to about mid-summer.

In British seas this species is known from the north coast of

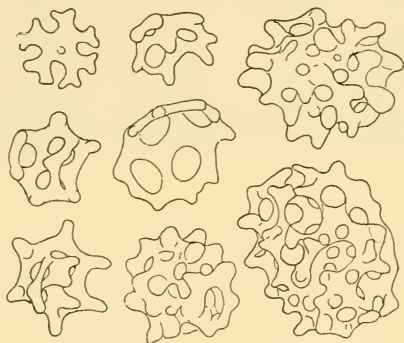


FIG. 252 —Calcareous deposits from the ventral sole of *Psolus phantapus*.
 × 145. (From *Danmark's Fauna*.)

Ireland (Blacksod Bay, Down), the west coast of Scotland (Clyde, Firth of Lorne), the Shetland Islands, and from Moray Firth and the Northumberland and Yorkshire coast on the east coast. No doubt it will be found all round the coast from the Clyde to Scarborough, and probably somewhat farther south. It is not known from south of the British area, while to the north it goes to the White Sea and Spitzbergen. Also known from Greenland and the American east coast, down to 42° N. Its bathymetrical distribution is from the littoral to 380 m.

2. *Psolus squamatus* Koren. (Fig. 253.)

(Syn. *Psolus Fabricii* Bell, Massy ; non Dübén and Koren.)

Body very flattened ; anterior and posterior end only very slightly or, when retracted, not at all prominent. Ventral sole very broad, oval, delimited from the dorsal side by a broad, thin, and sharp edge. Tube-feet usually wanting in the

mid-radius, excepting a few at each end; rarely a few are found scattered in the mid-line, very rarely a double row may be found along the mid-radius. Along the edges the tube-feet form a



FIG. 253.—*Psolus squamatus*; dorsal and ventral side. Nat. size.

conspicuous double row. Scales large, smooth, with sparse small grains on their surface. No small scales intermingled between the large ones on the mid-dorsal side, between mouth and anus.

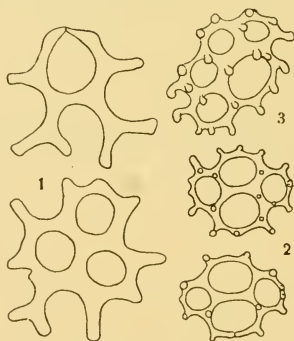


FIG. 254.—Deposits from the ventral sole of *Psolus squamatus* (1) and *Ps. valvatus* (2-3). 3. Half in side view in order to show the peculiar shape of the tubercles. $\times 145$. (From *Danmark's Fauna*.)

The grains on the scales flattened, ca. 0.15-0.2 mm. in diameter. The deposits of the ventral sole are small, delicate plates, smooth or with very few small tubercles (Fig. 254, 1). No cup-shaped bodies. All retractor muscles attached to the longitudinal muscles. Colour whitish-yellowish. Grows to a length of 6-7 cm.

Young specimens bear some resemblance to the following species, having generally, like the latter, 5 triangular oral valves; but they may be distinguished by the presence of some small scales inside the apex of the valves, and by the anal opening being surrounded by more small scales (in *Ps. valvatus* a single circle). From young *Ps. phantapus* they are distinguished by the absence in this latter species of the larger oral valves, the attachment of the dorsal retractor muscles in the interradii, by the deposits of the ventral sole, and by the different shape of the grains on the scales.

Development unknown. Sexual maturity is reached at a size of ca. 30 mm. length.

From British seas this species has not hitherto been recorded. The author having had the opportunity of examining some of the specimens recorded by Massy under the name of *Psolus Fabricii*,¹ finds that they really belong to *Ps. squamatus*, not to *Fabricii*, as might well be expected, *Ps. Fabricii* being an Arctic species, not known south of Iceland. The localities where *Ps. squamatus* was found, in abundance, are: 51° 20' N., 11° 35' W., 730-828 m., and off Eagle Island, Co. Mayo, 530-698 m. ("Helga"). Most probably also the specimens recorded in Bell's *Catalogue* from Shetland, under the name *Ps. Fabricii*, are referable to *squamatus*.

The species is known elsewhere with certainty only from the Norwegian coasts up to the Trondhjem Fjord. The various records of its occurrence at Greenland, the coasts of N. America, Japan, South Africa, etc., are uncertain and need verification. Bathymetrical distribution ca. 40-400 m.

3. *Psolus valvatus* Östergren. (Fig. 255.)

Body usually very flattened, anterior and posterior end not prominent. The mouth opening surrounded by 5 large, triangular valves which, when the opening closes, make a complete cover. The valves are interradially placed, sharply limited against the adjoining body scales. Sometimes one or more of the valves are divided into two lateral halves. No small plates are found inside the apex of the valves. Anal opening surrounded by a single circle of scales. Scales rather irregular, of various sizes, not distinctly imbricating. They are quite smooth; only in the

¹ Received from Dr. Stelfox, National Museum of Ireland, Dublin. *Psolus Fabricii*, though resembling in general *Ps. squamatus*, is easily distinguished by the much coarser granulation of its scales, and by the presence of both cups and flat, smooth plates in the ventral sole.

largest specimens (15-18 mm. length) some few small warts may be found on the oral valves. No tube-feet in the mid-ventral radius, and along the edge of the sole they are few and relatively large, apparently in a single series, those of the outer series being very small and difficult to see. Deposits of the ventral sole (Fig. 254, 2-3) delicate plates, usually provided with small, somewhat stalked tubercles. No cup-shaped deposits. The grains on the

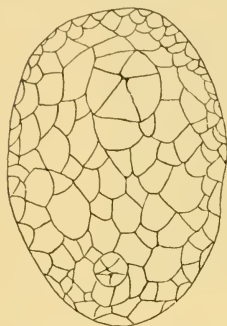


FIG. 255.—*Psolus valvatus*; dorsal side. $\times 6$. (From *Danmark's Fauna*.)

scales represented only by small microscopical, simple, perforate plates. Colour white or yellowish. Very small form, not known to exceed 18 mm. length.

It may be sexually ripe at a size of 10 mm. It appears to propagate normally through autotomy, by transverse division, each half regenerating the lacking part. Development otherwise unknown.

This species was not hitherto recorded from the British seas. But a specimen of the *Psolus* sp. recorded by Massy from west of Ireland, which was sent me for examination by Dr. Stelfox,

Dublin, proved to belong to *Ps. valvatus*. It is very probable also that several of the other specimens recorded by Bell, Kemp, and Massy are *Ps. valvatus*, which is probably fairly common in deeper water off the Irish west coast. It is known elsewhere only from the Norwegian coasts and West Greenland, from depths of ca. 20-500 m.

[IV. Order. MOLPADONIA Haeckel.]

Body thick, sausage-shaped, with a tail-like prolongation. Tube-feet absent, with the exception of 5 small papillae or groups of papillae round the anus. Tentacles simply finger-shaped or feather-shaped; tentacle ampullae usually present. Respiratory trees present. Retractor muscles may be present. Deposits calcareous plates, often with a spire or an anchor; often small, claret-coloured or yellowish bodies (phosphate concretions) are present.

All Molpadids live more or less completely buried in the ground, and feed on the bottom material, with which they fill their alimentary canal. Nothing is known about the development of any Molpadid.

The order comprises one family.

Family MOLPADIIDÆ

Diagnosis the same as that of the order.

No Molpadid is known from the British seas, but it is very probable that the genera *Trochostoma* Danielssen and Koren and *Ankyroderma* Danielssen and Koren will be represented there, or the genus *Molpadia* Cuvier, if these two genera cannot be kept separate from the latter, as is the opinion of H. L. Clark in his recent monograph of this order. Without taking a definite position towards the question, the author is here following H. L. Clark in regarding *Trochostoma* and *Ankyroderma* as synonyms of *Molpadia*.

1. *Molpadia* Cuvier. (Fig. 256.)

Tentacles 15, with 1-3 pairs of digits and a larger terminal digit. Body stout, with a distinct but short "tail". Radial pieces of calcareous ring with conspicuous bifurcate posterior



FIG. 256.—*Molpadia arctica*. Slightly reduced. (After Danielssen and Koren, *Norwegian North Atlantic Exp. Holoth.*)

prolongations. Calcareous deposits tables, often in very imperfect state, perforate plates or more or less fusiform rods. Anchors usually present, though often very scarce, attached to racquet-shaped plates, usually arranged so as to form a rosette (Fig. 257, 1). Phosphatic deposits often present. Anal teeth usually present.

Seven species of this genus are known from the N.E. Atlantic and the Arctic European seas, namely *Molpadia albicans* Théel¹ (Syn. *Trochostoma albicans* Théel), found at 16° 38' N., 20° 44' W., 3200 m. ("Talisman"), elsewhere known from the east coast of N. America and the Indo-Pacific, 486-3200 m.; *M. arctica* (v. Marenzeller) (Syn. *Haplodactyla arctica* v. Marenz.), from East Greenland to Finmark and the Kara Sea, ca. 200-400 m.; *M. blakei* (Théel) (Syn. *Trochostoma blakei* Théel; *Tr. blakei*, var.

¹ H. L. Clark refers this species to the genus *Caulina*

excentrica Hérourard; *Tr. grossularia* Hérourard),¹ Bay of Biscay to Senegal, 2779-5000 m. ("Talisman", "Princesse Alice"), elsewhere known from the West Indies, 1720 m. ("Blake"); *M. loricata* (Perrier) (Syn. *Ankyroderma loricatum* Perrier), off Portugal to Cape Verde, 1090-2324 m. ("Talisman", "Princesse Alice"); *M. maroccana* (Perrier) (Syn. *Ankyroderma maroccanum* Perr.), 30° 9' N., 14° 1' W., 2210 m. ("Talisman"); *M. musculus*



FIG. 257.—Calcareous deposits of Molpadids. (1. After Danielssen and Koren, *Holoth. Norweg. N. Atl. Exp.* 2-6. After Perrier, "Talisman" *Holoth.*)

1. Anchor and anchor plates of *Molpadia oolithica*. 2. Deposit of *M. albicans*. 3. Deposits of *M. blakei*; side view and from above. 4-5. Smaller and larger plate of *M. maroccana*. 6. Fusiform deposit from *M. musculus*. 1. \times ca. 35; 2 and 6, \times ca. 100; 3, ca. 135; 4-5, \times ca. 45.

Risso (Syn. *Haplodactyla mediterranea* Grube, *Ankyroderma musculus* (Risso), *A. Perrieri* Petit, *A. hispanicum* Petit, *A. Danielsseni* Théel, *Trochostoma violaceum* Théel), from off Portugal and the Canaries, 106-1139 m. ("Talisman"), elsewhere found in the Mediterranean, off the east coast of N. America, the Antarctic and Indo-Pacific Seas, thus rather cosmopolitan; *M. oolithica* (Pourtalès) (Syn. *Molpadia borealis* Sars; *Trochostoma Thomsoni*

¹ The only character distinguishing the var. *excentrica* and *Tr. grossularia* from *M. blakei* appears to be the eccentric position of the tail, which may perhaps be due to contraction on preservation; as, moreover, it is not known whether or not the tail of the typical *blakei* is likewise eccentric, there is, for the present at least, no reason for maintaining these forms as separate from *M. blakei*.

Dan. and Kor.; *Ankyroderma Jeffreysi* Dan. and Kor.; *A. affine* Dan. and Kor.¹; *Molpadia Jeffreysi*, var. *gracilis* Hérouard), from Spitzbergen and the Kara Sea to 62° N. in the Norwegian sea, from Greenland to the West Indies; also recorded from the N. Pacific, ca. 100-1000 m.

The great variability of the calcareous deposits in *Molpadia* makes the identification difficult, and has caused the establishment of altogether too many "species", as appears from the lists of synonyms given above.

Key to the species of Molpadia known from the N.E. Atlantic.

1. Deposits smooth 2
 Deposits thorny (Fig. 257, 2) ("Challenger" *Holoth.*, ii., p. 44, Pl. III. 2) *M. albicans* (Théel)
2. Fusiform bodies (Fig. 257, 6) present all over the body (Ludwig, "Ankyroderma musculus", *Zeitschr. wiss. Zool.* 51, 1891)
 M. musculus Risso
 Fusiform bodies mainly in the tail, or absent 3
3. Deposits larger, irregular, fenestrated plates (Fig. 257, 4-5) 4
 Deposits tables, usually with 3 holes and a spire (Fig. 257, 3) 5
4. Fenestrated plates of two kinds, larger, with fewer, larger holes, and smaller, with numerous smaller holes ("Talisman" *Holoth.*, p. 533, Pl. XXII. 9-15) *M. maroccana* (Perr.)
 Fenestrated plates of only one kind ("Talisman" *Holoth.*, p. 535, Pl. XXII. 23-28) *M. loricata* (Perr.)
5. Phosphatic bodies present (Norwegian North Sea Exp. *Holoth.*, p. 42, Pls. VII.-IX.) *M. oölitica* (Pourt.)
 Phosphatic bodies absent 6
6. Tables very small, regular, ca. 0.10 mm. in diameter; holes not pointed; spire ca. 0.15 mm. high or more (Théel, "Blake" *Holoth.*, p. 16; "Monaco", lxvi., p. 137, *Tr. grossularia*)
 M. blakei (Théel)
 Tables larger, spire proportionally lower; disks more or less irregular, often with prolongations, holes usually somewhat outwards pointed (Marenzeller, "Coelent. Echinod. Würmer", *Österreich. Nordpol-Exped.*, p. 29, Taf. IV.)
 M. arctica (Marenz.)

V. Order. APODA Brandt.

(Syn. *Paractinopoda* Ludwig.)

Tube-feet entirely absent, even the radial water-vessels usually undeveloped. Tentacles feather-shaped or with only few side branches, more rarely simply digitate. Retractor muscles usually absent. No tentacle ampullæ; no respiratory trees.

¹ H. L. Clark regards *Ankyroderma affine* as a separate species, *Molpadia affinis*.

The numerous forms belonging to this order are either regarded as forming one family, with three subfamilies, or as forming three families; which course is to be taken is rather a matter of taste. The distinguishing characters of the three groups being found in the calcareous deposits alone, and thus not of primary morphological importance, it may well be preferable to regard all as belonging to one family.

I. Family SYNAPTIDÆ

Body elongate, worm-shaped. Calcareous ring often with more than five interradiar pieces; radial pieces often perforate. Small ciliated funnels usually present in the body cavity. No Cuvierian organs. A pair of statocysts at the base of each radial nerve. Calcareous deposits mainly anchors and anchor plates, wheels or sigmoid bodies.

Key to the subfamilies of the Synaptidæ.

- | | |
|---|-------------------------|
| 1. Deposits anchors and anchor plates (rarely absent) | 1. <i>Synaptinæ</i> |
| Deposits wheels or sigmoid bodies | 2 |
| 2. Wheels with only 6 spokes; sigmoid bodies often present together with the wheels or sigmoid bodies alone | 2. <i>Chiridotinæ</i> |
| Wheels with 8 or more spokes | 3. <i>Myriotrochinæ</i> |

I. Subfamily SYNAPTINÆ

Deposits of body wall anchors and anchor plates; small irregular or ovoid bodies often present. Deposits rarely absent. Small rod-shaped spicules in the tentacles. In the larvæ and, sometimes at least, also in the young specimens wheels are present.

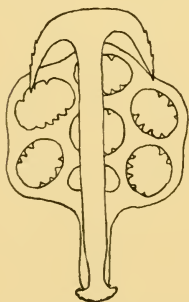


FIG. 258.—Anchor and anchor plate of *Labidoplax Buski*, as they lie together in the body wall. $\times 200$. (From *Danmark's Fauna*.)

Anchor and anchor plate are separate bodies, but always closely associated so as to form apparently a single body (Fig. 258). They serve as locomotory apparatus. They are enclosed by the skin, but on handling their anchors very easily break through the epidermis and thus make the skin exceedingly sticky; especially in the larger tropical forms the anchors will hold very tenaciously in each other or in what else they get hold of, and it may be difficult enough to separate them from each other

and get the specimens preserved in an extended state. It is also usually necessary to narcotise the specimens (*e.g.* with magnesium

sulphate) in order to get them well preserved. The plates always lie horizontally, parallel to the circular muscles, the anchor lying outermost. The basal part of the anchor, the handle, is a little widened, with the edge very finely serrate or ramified. Above the handle the shaft is somewhat compressed and has on the inner side an arched keel, which serves as an articular surface, on which the anchor moves in relation to the anchor plate. The arms of the anchor, which are usually somewhat thorny, are directed slightly outwards. The anchor plate is usually somewhat narrower in the basal part, where it is connected with the anchor and is often provided with an outwardly curved bow. There are no special anchor muscles, but the whole apparatus is surrounded by connective fibrillæ. Movement is caused only by the contraction of the body wall. When the body wall is extended, the tissue surrounding the anchor is tightened and the anchor is pressed downwards on to the plate (Fig. 259, B); the anchor arms become erect, forming a projection on the skin, which acts as a small foot. The points of the anchor arms do not pierce the skin; they thus act in a similar way as the ribs of the snakes. When the body wall relaxes, the anchor rises from the anchor plate, the point of the arms then being directed inwards (Fig. 259, A). The holes in the anchor plate are generally serrate along the edge; they usually show a very constant and regular arrangement, which is of importance for classification.

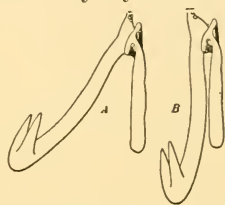


FIG. 259.—Anchor and anchor plate of a Synaptid in two different positions, side view. In A by relaxed, B by extended, body wall. Diagrammatic. (After Östergren; from *Danmark's Fauna*.)

Two genera of the subfamily *Synaptinae* are known from the British seas, but two more are very likely to be represented there also, viz., *Protankyra* Östergren, the species *Pr. abyssicola* (Théel) (*Synapta abyssicola* Théel)¹ having been found in the Bay of Biscay, 4870 m. ("Princesse Alice"), and off Senegal, 3200 m. ("Talisman"), also known from the West Indies and the east coast of N. America, 2259-4870 m.; *Rhabdomolgus* Keferstein, the only species known, *Rh. ruber* Keferstein, having been found at Brittany and Heligoland, in ca. 20 m.²

¹ For a description of this species see "Challenger" Holoth., ii., p. 14, Pl. I. 11; H. L. Clark, *The Apodous Holothurians*, p. 105, Pl. IV. 8-11.

² Hérouard ("Monaco", lxxvi., p. 141) also records *Synaptula hydriformis* (Lesueur) from the Azores, 1250 m., though with a question mark, as he had

Key to the genera of Synaptinæ known from or likely to occur in the British seas.

1. Calcareous bodies (anchors and anchor plates) present 2
- ,, ,, absent *Rhabdomolgus* Keif.
2. Anchor plate narrowed into a distinct handle (Fig. 258) 2. *Labidoplax* Östergren
- Anchor plate not narrowed into a distinct handle 3
3. Anchor plate irregular, with numerous small holes (Fig. 260) *Protankyra* Östergren
- Anchor plate more regular, with larger, regularly arranged holes (Fig. 262) 1. *Leptosynapta* Verrill

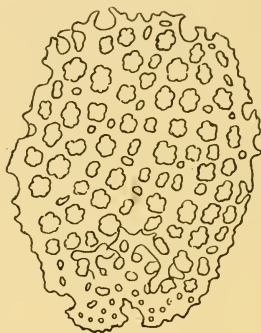


FIG. 260.—Anchor plate of *Protankyra abyssicola*. × 70.
(After H. L. Clark, *Apodous Holothurians*.)

1. *Leptosynapta* Verrill.

Basal part of anchor plate gradually narrowing, not having the shape of a narrow handle, sharply set off from the outer part of the plate.

Transparent forms, of small or moderate size, which live buried in the ground, in sandy or muddy bottom. They feed on the bottom material, which they ingest by means of their tentacles.

Only one species is known from the British seas, but four other species are very likely to be found there also, namely, *Leptosynapta bergensis* Östergren, known from the Trondhjemfjord to Heligoland, as also from the Faroe Islands; *L. decaria* (Östergren), known from Trondhjemfjord to the Kattegat;

only a fragment without any calcareous deposits. It is exceedingly improbable that this was really identical with the West Indian littoral *Synaptula hydriformis*, and there is no reason to expect this species to be represented in European seas.

L. Galliennii (Herapath), from the Atlantic coasts of France; and *L. minuta* (Becher), known only from Heligoland. All of them are littoral forms, not known from depths beyond ca. 50-70 m. As these species are probably all found in the British seas, but have been overlooked or confused with *L. inharens*, it has been thought preferable to give descriptions of them and not only give their characters in the key.

Key to the species of Leptosynapta known from or likely to occur in the British seas.

- | | |
|---|-------------------------------------|
| 1. Tentacles 10 | 2 |
| „ usually 12 (10-13) ¹ | 3 |
| 2. Tentacles simple. Besides anchors and anchor plates (Fig. 262, 4), small plates with 4 holes are found. Viviparous | |
| | <i>L. minuta</i> (Becher) |
| Tentacles usually with 2-4 pairs of digits. No 4-holed plates in the body wall. (Anchors, Fig. 262, 3) . | <i>L. decaria</i> (Östergr.) |
| 3. Tentacles usually with 5-7 pairs of digits, increasing in length distalwards. Intestinal canal straight; no muscular stomach | |
| | 1. <i>L. inhærens</i> (O. F. Müll.) |
| Tentacles usually with 8-9 pairs of digits, not increasing in length distalwards. The intestinal canal forms a loop; a muscular stomach present | 4 |
| 4. Anchor plates of anterior end of body with serrate edge (Fig. 263) | |
| | <i>L. Galliennii</i> (Herap.) |
| Anchor plates of anterior end of body in the main smooth (Fig. 262, 1) | <i>L. bergensis</i> (Östergr.) |

1. *Leptosynapta inhærens* (O. Fr. Müller). (Fig. 261.)

(Syn. *Synapta inhærens* (O. Fr. Müll.) ; *Synapta duvernœa*
Quatrefages.)

Tentacles 12 (exceptionally 10, 11, or 13), with mostly 5-7 pairs of digits, increasing in length distally, the outermost ones being distinctly longer than the middle ones; the unpaired terminal digit is the longest. Alimentary canal not forming a loop; no muscular stomach. Ciliated funnels in three longitudinal rows, in median and left dorsal interradius and in right ventral interradius; at least in the left dorsal interradius they form a close series in the whole length of the body; in younger specimens they may be almost totally wanting in the mid-dorsal interradius. Usually a single Polian vesicle. Calcareous ring

¹ The number of the tentacles of the *Leptosynapta* species is not quite constant, so that it does not offer a wholly reliable specific character, and the other characters should always be verified in order to obtain a reliable identification.

consisting of 12 pieces (2 interradaia in right and left dorsal interradius); radiaia perforated. Genital opening in the point of one of the tentacles (usually the uppermost to the right of the dorsal mid-line). Anchor usually narrower than the anchor plate (Fig. 262, 2); the outer, free part of the anchor plate with 6, rarely 7, serrate holes round the central hole; the outermost



FIG. 261.—*Leptosynapta inhaerens* (to the left), *Labidoplax buski* (in the middle), *Myriotrochus vitreus* (to the right). The curvature of the posterior end of *L. inhaerens* accidental. Nat. size. (From *Danmark's Fauna*.)

hole mostly, though not always, distinctly larger than the others. Often a few small, mostly smooth holes are found along the outer edge of some of the plates. Small calcareous bodies are found in the longitudinal muscles. Colour in life a faint pinkish. Grows to a size of ca. 30 cm. length, but a length of 10-18 cm. is the more usual.

Lives buried in the ground, in sand or mud, or among *Zostera*. It is hermaphrodite. The eggs are very small; nevertheless it has not a typical pelagic larva but direct development.

Numerous parasites or commensals are found on or in this or the other Synaptids of the European coasts,¹ e.g. the Gregarines *Urospora synaptæ* Cuénot and *Gonospora Mercieri* Cuénot, the Infusorians *Urceolaria synaptæ* Cuénot and *Rhabdostyla arenaria* Cuénot, various Cercarians and Planarians, the Rotatorian *Discopus synaptæ* Zelinka, the Tardigrade *Tetrakentron*

synaptæ Cuénot (among the tentacles, where also the *Discopus* especially abounds), the Copepod *Synaptiphilus luteus* Canu and Cuénot (in the œsophagus), the Polynoids *Harmothoe lunulata* (D. Chiaje) and *H. marphysa* M'Intosh, the Lamellibranch *Entovalva Perrieri* Malard (on the skin of *L. inhaerens*, found only at St. Vaast la Hougue), and—the most remarkable of all—the

¹ See especially L. Cuénot, "Contributions à la Faune du bassin d'Arcachon. V. Échinodermes", *Bull. Station Biol. d'Arcachon*, xiv., 1912, pp. 68-92.

Gastropod *Entoconcha mirabilis* Joh. Müller, known only from *L. digitata* from the Adriatic.

In British seas *Leptosynapta inhærens* appears to be common along the west coasts from Plymouth to the Shetlands; also recorded from the Firth of Forth and St. Andrews on the east coast. It is elsewhere known with certainty from Lofoten on the Norwegian coast to the Atlantic coasts of France, whereas it is perhaps doubtful whether the "*inhærens*" of the Mediterranean is really identical with the north European form. Likewise it is

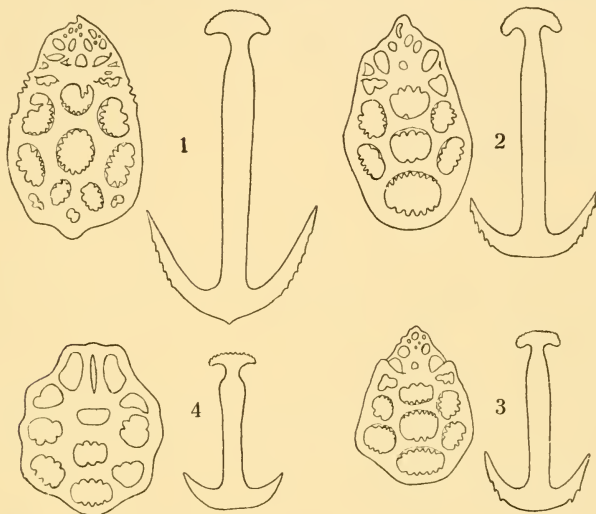


FIG. 262.—Anchor plate and anchor of *Leptosynapta bergensis* (1), *L. inhærens* (2), *L. decaria* (3), and *L. minuta* (4). (After Östergren (1-3) and Becher (4).) 1, \times ca. 80; 2-3, \times ca. 135; 4, \times ca. 340. (From *Danmark's Fauna*.)

doubtful whether the North American and Japanese "*inhærens*" are really that species. Bathymetrical distribution also rather uncertain, on account of the former insufficient distinction of the species, but it occurs at any rate from within tide marks down to 50 m.¹

[*Leptosynapta bergensis* (Östergren).²] (Fig. 262, 1.)

Tentacles 12, usually with 8-9 pairs of digits, which are all short and, excepting the proximal pairs, equally long; also the

¹ It is recorded from a depth of 173 m. in the Bay of Biscay ("Porcupine" Stat. 35).

² Usually this species is regarded as identical with *L. Galliennii* (Hera-path). The difference in the anchor plates would, however, seem to be too great for simply uniting them, and the present author thinks it more correct to follow Östergren in regarding them as separate species.

terminal digit quite short. Alimentary canal forming a loop, the ascending part united with the descending part by a transverse vessel; just behind the calcareous ring a well defined thick-walled portion, a muscular stomach. Polian vesicle single. Ciliated funnels rather scarce, only in one longitudinal series, in the left dorsal interradius, and mainly in the anterior end. Calcareous ring with 12 pieces; radialia perforated. Genital opening as in *inhærens*, in the point of one of the dorsal tentacles. Anchor usually broader than the anchor plate (Fig. 262, 1); the hole outside the central hole often divided into two or more smaller ones; besides there are generally some smaller, partly serrate holes along the outer edge, which latter may also be more or less serrate. Anchor and anchor plate conspicuously larger than in the other north European species.¹ (Cf. the various enlargements in Fig. 262.) Small C-shaped bodies in the skin. Colour red-pinkish. Reaches a length of ca. 30 cm., more usually ca. 12-20 cm. long, by a thickness of 5-9 mm.

The variety *makrankyra* Lüdwig, from the Mediterranean, characterised by the considerable size of the anchors, up to 0.8 mm. long, has also been found on the Atlantic coasts of France (Dinard).

Development unknown.

The species is known from the Scandinavian coasts, from Trondhjem to Bohuslén, and in the North Sea down to Heligoland. It is also known from the Faroe Islands. Bathymetrical distribution as *L. inhærens*.

[*Leptosynapta Galliennii* (Herapath).] (Fig. 263.)

(Syn. *Synapta sarniensis* Herapath.)

Very much like *bergensis* in regard to general shape and anatomy, as also in colour and size. But it differs markedly from

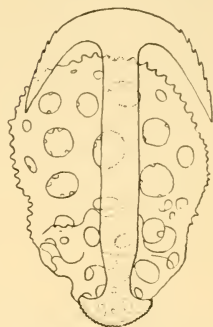
¹ The average size of anchors and anchor plates in the north European *Leptosynapta* species are as follows, measured in μ . (No such measurements are given for *L. minuta*.)

	Anchor.		Anchor Plate.	
	Length.	Breadth.	Length.	Breadth.
<i>L. bergensis</i> .	300-400	175-225	250-325	150-200
<i>L. inhærens</i> .	200-250	100-120	175-200	115-135
<i>L. decaria</i> .	150	95	130	105

that species in the edge of the anchor plates, especially those of the anterior body end,¹ being serrate, while in *bergensis* the edge is always in the main smooth, only with some few serrations here and there, mainly in the lower part. Also the size of the anchors and their plates is slightly larger in *Galliennii*.

Development unknown.

The species is known with certainty only from the Atlantic coasts of France, from the littoral region. It appears here in some places to exclude *L. inhærens*.



[*Leptosynapta decaria* (Östergren).]
(Fig. 262, 3.)

FIG. 263.—Anchor and anchor plate of *Leptosynapta Galliennii*.
× 155.

Tentacles 10, with 2-4 pairs of digits, increasing in length distally; unpaired terminal digit the longest. Alimentary canal straight; no muscular stomach. Two to three Polian vesicles. Ciliated funnels rather large, scarce, in a single series in left dorsal interradius. Calcareous ring with 10 pieces; radialia perforated. Anchor usually narrower than anchor plate. Six serrate holes round the central hole, the outermost one usually a little larger than the others (Fig. 262, 3); sometimes 1-3 more small holes along the outer edge. Colour whitish. Size, 1.5-5 cm. long by 1.5-3 mm. thick. Development unknown.

Hitherto known only from the Trondhjem Fjord to the Kattegat, in 40-70 m. depth.

[*Leptosynapta minuta* (Becher).] (Fig. 262, 4.)

Tentacles 10, simple, without digits. Alimentary canal straight, simple. One Polian vessel; only a single ciliated funnel. Calcareous ring of 10 pieces, all of the same simple dumbbell-shape; radialia not perforate. Anchor narrower than the plate; the latter with only 3 holes in the articular end, the middle one very narrow, slit-like (contrary to the other species, which have several small, irregularly arranged holes in the articular end of the anchor plate). Besides the anchors and plates also small plates with 4 holes. Quite transparent, without

¹ In the posterior end of the body the plates are more like those of *bergensis*, with the edge in the main smooth. On the whole there is usually a more or less conspicuous difference in Synaptids between the deposits of the anterior and posterior ends of the body. (Cf. e.g. *Labidoplax digitata* and *Thomsoni*.)

pigment. Very small form, scarcely more than 1 cm. long. It is viviparous, the young ones developing in the body cavity.

The anchor plate may be incomplete at the articular end, the two outer holes wanting. Such plates then have the shape characteristic of the genus *Labidoplax*, with a narrow handle. *L. minuta* in reality occupies an intermediate position between the genera *Leptosynapta*, *Labidoplax*, and *Rhabdomolgus*.

Hitherto known only from off Heligoland, where it occurs on muddy bottom, ca. 20 m.

2. *Labidoplax* Östergren.

Basal part of the anchor plate has the shape of a narrow handle, sharply set off from the outer part of the plate. Tentacles with only 1-2 pairs of digits.

Three species of this genus known from the British seas; a fourth, *Labidoplax media* Östergren, known only from off Bergen, may well be expected to occur there also.

Key to the species of Labidoplax known from or likely to occur in the British seas.

1. Tentacles 11, with a long terminal and 1 pair of smaller lateral digits. Gonads simple tubes 1. *L. Buski* (M'Intosh)
Tentacles 12; no terminal digit, but 2 pairs of lateral digits at the end of the tentacle 2
2. Anchor plate of regular shape (as in *L. Buski*, Fig. 264). Gonads branched. Small form, 3-4 cm. long.¹ *L. media* Östergren.
Anchor plate of irregular shape; large forms, up to 30 cm. long 3
3. Anchor plates in anterior end of body thick and of complicated structure, with serrate edge; handle short and broad, with several small holes 3. *L. Thomsoni* (Herap.)
Anchor plates all flat, simple, with edge smooth; handle narrow, with an elongate, slit-like median hole 2. *L. digitata* (Mont.)

1. *Labidoplax Buski* (M'Intosh). (Fig. 261.)

(Syn. *Synapta tenera* Norman.)

Tentacles 11 (very rarely 10 or 12), with one pair of lateral digits and a very long terminal digit. The alimentary canal forms a short loop in the middle of the body; the ascending part is connected with the first descending part by a transverse

¹ For a detailed description of *Labidoplax media* cf. Hj. Östergren, "Zur Kenntniss der skandinavischen u. arktischen Synaptiden", *Arch. Zool. expér. et génér.* (4), iii., 1905, p. clviii.

vessel. No muscular stomach. Gonads only one long, unbranched tube on each side the dorsal mesentery; genital opening at the base of the dorsal tentacles. Ciliated funnels appear to be wanting. Calcareous ring consisting of 11 pieces, there being 2 interradiania in the mid-dorsal interradius. Radials perforate. Anchors narrower than the anchor plates; the latter of a fairly regular shape, with 6 serrate holes of about equal size; the handle narrow, with one or two more or less slit-like holes (Fig. 264). Colourless, or, when the genital organs are strongly developed, faintly reddish-yellow. Reaches scarcely more than ca. 3 cm. length.

Lives in muddy bottom. Development unknown; but the large, yolky eggs would seem to indicate that the development is direct, without an Auricularia stage. In young specimens Auricularia wheels may occur in the posterior end, even in specimens up to 2 cm. long.

In British seas this species is known only from the Clyde and the Hebrides (Sound of Harris). It is elsewhere distributed from Finmark to Kattegat on the Scandinavian coasts, in depths of ca. 10-420 m.



FIG. 265.—Tentacle of *Labidoplax digitata*, showing the two groups of sensory organs. $\times 10$. (After Cuénot, *Contrib. Faune d'Arcachon: Echinodermes*.)

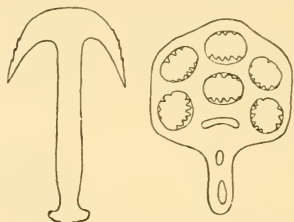


FIG. 264.—Anchor and anchor plate of *Labidoplax Buski*. $\times 200$. (From *Danmark's Fauna*.)

2. *Labidoplax digitata* (Montagu).¹ (Figs. 265, 266.)

(Syn. *Synapta digitata* Mont.)

Tentacles usually 12, with 2 pairs of lateral digits, the outer the largest; the terminal digit is rudimentary or absent. The inside of the tentacle presents two longitudinal series of small round sensory organs (Fig. 265), and at the base a small pigmented spot (eye?) between the tentacles. The alimentary canal forms a loop; muscular stomach present. Gonads dichotomous tubes. Genital opening at the base of the dorsal tentacles. Ciliated funnels small, but very numerous, in a series throughout almost the whole body length in the mid-dorsal

¹ A good figure of the animal is given in Bell's *Catalogue*, Pl. VII. 1-2.

and the right dorso-lateral interradius. Calcareous ring consisting of 12 pieces; the radials perforate. The anchor plates are more or less regular, racquet-shaped, with a narrow handle and usually 4 larger central holes in the plate; the holes are smooth, as is also the edge of the plate. The plates are somewhat smaller in the anterior than in the posterior end of the body. The anchors are ca. 0.3-0.35 mm. long, with arms much diverging; the arms are serrate. Giant anchors are sometimes found, lying in a regular series in each dorso-lateral interradius; their arms, which are

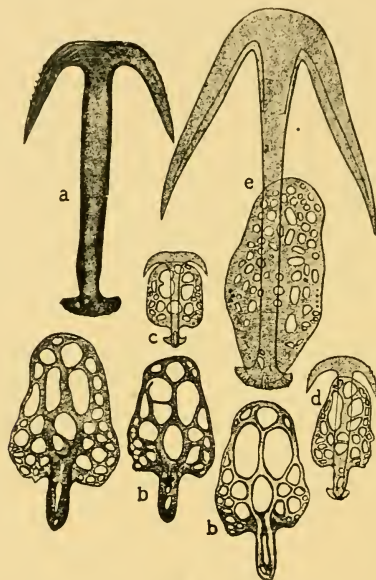


FIG. 266.—Deposits of *Labidoplax digitata*. $\times 70$. (After Kochler, *Échinodermes, Faune de France*.)

a, Anchor; *b*, Anchor plate; *c*, Anchor and plate from anterior end of body; *d*, Same from about the anterior fourth of body; *e*, Giant anchor and plate.

smooth, are much less diverging than in the usual small anchors. This form of anchor is 0.8-0.9 mm. long, while the plate is only 0.3-0.4 mm. long; the latter differs from the usual plates in having numerous small irregularly arranged holes (Fig. 266). Numerous small oval bodies in the body wall and, especially, in the longitudinal muscles. Colour in life red or brownish, the ventral side lighter. Reaches a length of ca. 30 cm.

Lives in muddy-sandy bottom, from within tide limits down to ca. 70 m. The larva is a typical Auricularia (Fig. 3, 1), with a few wheels in the postero-lateral lobes. Breeding season in the

summer-time (in the Mediterranean apparently almost throughout the year).

The variety *profundicola* Kemp is stated to differ from the typical *digitata* in the anchor plates, which are "far more irregular and of a lighter build. They are roughly triangular in shape, with six large primary holes, three at the base near the handle, two larger ones in the middle, and a single one at the apex. . . . The primary perforations are often completely or incompletely divided by a narrow bar." Colour deep purple.¹

In British seas *Labidoplax digitata* appears to be distributed all around the western coasts, from Plymouth to the Shetlands, whereas it does not appear to be found on the east coasts. It is otherwise known from the Atlantic coasts of France and the Mediterranean. Bathymetrical distribution from within tide limits to ca. 70 m. The variety *profundicola* is recorded from off W. Ireland, from 66-268 m.

3. *Labidoplax Thomsoni* (Herapath). (Fig. 267.)

(Syn. *Synapta digitata*, var. *Thomsoni* Herapath.)

In general aspect like the preceding species, but differs from it in lacking the groups of sensory organs on the inside of the tentacles. In the internal anatomy it is not known to differ from the preceding species.² The calcareous deposits offer the main distinguishing characters of the species (Fig. 267). They are markedly different in the anterior and posterior ends of the body. In the anterior end the anchor plates are rounded, with serrate edge, and consist of a complicated, thick, irregular network, not a simple flat plate as otherwise usual in Synaptids; they are opaque, almost black, only the very short handle being of the usual transparency. They are usually ca. 0.15 mm. long. The anchors are short, with arms very divergent. Towards the posterior end of the body the plates gradually become thinner, the thick, secondary network disappearing; these plates are

¹ As no figures are given of the calcareous deposits of this form, and as, moreover, the figures given in Bell's *Catalogue* (Pl. I. 3) as representing the calcareous bodies of *L. digitata* (which have served for comparison) are partly (viz. the two figures with serrate holes) not of this species, but of *L. Buski*, it is very difficult to form a definite opinion of the value of this variety *profundicola* (Stanley W. Kemp, "The Marine Fauna of West Ireland", iii., *Ann. Rep. Fish. (Ireland)*, 1902-3, Part II., App. VI. (1905), p. 184).

² The author has not had the opportunity of examining specimens of this species.

more like those of *digitata*, but the handle is shorter and broader and with more holes. No giant anchors are found. Colour and size as in *L. digitata*.

In British seas this species is known only from the locality

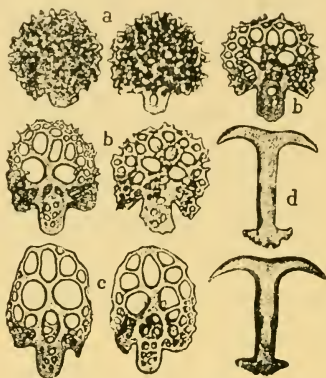


FIG. 267.—Anchor plates (a-c) and anchors (d) of *Labidoplax Thomsoni*.
× 100. (After Koehler, *Échinodermes, Faune de France*.)

a, From the anterior part of body ; b, from about the anterior fourth part ;
c, from the middle and the posterior part of body.

where Herapath got his original specimen, viz., Carrickfergus, on the Antrim shore of Belfast Lough. That it will prove to have a wider distribution along the south and west coasts cannot be doubted. It is known elsewhere from the Atlantic coasts of France and from the Mediterranean, occurring together with *L. digitata*.

[*Rhabdomolgus* Keferstein.]

Calcareous deposits absent. Tentacles 10, simple, finger-shaped.

Only one species known.¹

Rhabdomolgus ruber Keferstein. (Fig. 268.)

Alimentary canal straight ; no muscular stomach. One Polian vesicle, 1 stone canal ; no ciliated funnels. Gonads only a single, sac-shaped, unbranched tube. Genital opening behind the dorsal tentacles. Calcareous ring consisting of 10 dumbbell-shaped pieces. Colour intense red. Does not exceed ca. 1 cm. length.

Lives on rather coarse sand, apparently not buried in the

¹ The *Rhabdomolgus novæ-zealandiæ* Dendy and Hindle does not really belong to this genus.

ground. Development unknown, but apparently it has no Auricularia stage.

Hitherto known only from off Brittany and Heligoland. That it will occur in the British seas cannot be doubted.

[II. Subfamily CHIRIDOTINÆ]

Deposits of body wall wheels with 6 spokes; sigmoid bodies often present, sometimes sigmoid bodies alone.

Only one genus represented in the N.E. Atlantic.

Chiridota Eschscholtz.

Tentacles 12. No sigmoid bodies. Wheels collected in papillæ.

One species, *Chiridota abyssicola* v. Marenzeller, has been found off the Azores, 2870 m. ("Hirondelle"; only one specimen known); it may well be expected to occur also off the British coasts. The Arctic species, *Chiridota lævis* (Fabricius), which is not known farther south than the Lofoten Islands, is scarcely to be expected to occur within the British area.

[III. Subfamily MYRIOTROCHINÆ.]

Deposits of body wall wheels with many spokes (Fig. 269); no sigmoid bodies.

Three genera are represented in the northern and Arctic seas, namely, *Acanthotrochus* Dan. and Kor., with the species *A. mirabilis* Dan. and Kor., known only from between Norway and Spitzbergen, ca. 1200-2030 m.; *Myriotrochus* Steenstrup, with the two species *M. Théeli* Östergren, known only from off Jan Mayen, ca. 2000 m.; and *M. vitreus* (M. Sars) (Syn. *Oligotrochus vitreus* M. Sars), known from ca. 68° N. on the Norwegian coast to Skagerrack, in ca. 100-700 m.¹; and *Trochoderma* Théel, with the species *Tr. elegans* Théel, known from the Kara Sea to East

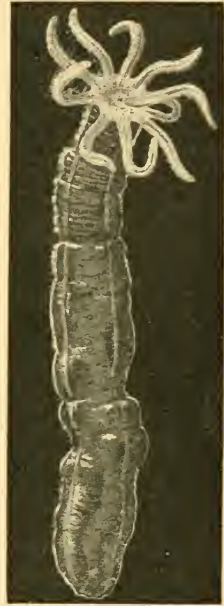


FIG. 268.—*Rhabdomolgus ruber*. $\times 8$. (After Becher, *Rhabdom. ruber*.)

¹ A third species of *Myriotrochus*, *M. Rinkii* Steenstrup, is an Arctic littoral species which cannot be expected to occur as far south as the British area.

APPENDIX

AFTER he had completed the manuscript of the present work the author received from Mr. G. P. Farran, Dublin, some small Echinoderms from the deep sea off the Irish west coast, among which were two sea-stars new to the fauna of the British seas, namely :

HOPLASTER SPINOSUS, E. Perrier ($51^{\circ} 22' N.$, $12^{\circ} 41' W.$; 982 fms.), and

PEDICELLASTER TYPICUS, M. Sars ($54^{\circ} 17' N.$, $11^{\circ} 34' W.$; 550 fms.).

Both these species have been included as species very likely to occur in the British seas, and it must suffice to refer to the places where they are mentioned and their main characters given, viz. p. 77 (*Hoplaster spinosus*) and p. 130 (*Pedicellaster typicus*). The very few specimens of *Hoplaster spinosus* hitherto known are all very young, not exceeding 7 mm. R.; the specific characters, therefore, are not known with certainty. But the characters given above easily distinguish *Hoplaster* from all other Asteroids of the North Atlantic. The general shape is very much like that of *Odontaster mediterraneus* (Fig. 42), but the absence of the large recurved spine on the jaw at once distinguishes *Hoplaster* from the latter species.

ECHINASTER SEPOSITUS (p. 117). In the opinion of W. K. Fisher (*Ann. Mag. Nat. Hist.* 9. ser. xviii. p. 196) the species name *sepositus* must be changed into *sagenus* Retzius. The present author is not of opinion that this very undesirable change of a name hitherto in constant use is needed, even on a strict application of the priority rule. (Cf. *Ann. Mag. Nat. Hist.* 9. ser. xvi. p. 544.)

Ad. p. 259. Instead of the name *tridentate pedicellariæ* some authors are using the name *tridactyle pedicellariæ*. The former name, however, decidedly has the priority, dating from 1788 (O. Fr. Müller), the latter dating from 1841 (Valentin). There is thus no doubt that the designation *tridentate* is the one to be used.

Ad. p. 263. To the parasites of the Echinoids should be added : *Cryptochilum boreale* Hentschel, which appears to be common in the intestine of *Echinus esculentus*.

Ad. p. 277. PLESIODIADEMA ANTILLARUM. This species was also dredged by the "Talisman" off the Canaries, in 2000-2100 m.

Ad. p. 292. *GENOCIDARIS*. A new species of this genus was dredged by the "Talisman" at the Canaries, 30 m. It differs from *G. maculata* mainly in the smaller size of the anal plate, in the ambulacral midline being sunk, in its apical part, and in its splendid red colour. Whether there is any prospect of finding this species within the British area it is impossible to say at present. A description of this species will be given by the author in a note on the Echinoids of the "Talisman" to be published in the *Bull. du Mus. d'Hist. Nat., Paris*, 1927. In this note will also be found some information on the characters of *Hygrosoma uranus*. (Cf. p. 286.)

Ad. p. 313. The LARVA of *STRONGYLOCENTROTUS DRÖBACHIENSIS*. According to information kindly furnished by Dr. S. Runnström, Bergen, this larva, in its I. stage, is characterized by having a rudimentary recurrent rod, much as in the larva of *Paracentrotus lividus* (Fig. 177, b). The shape of the body rod appears to vary rather considerably, being generally somewhat irregularly widened, much as in *Psammechinus miliaris* (Fig. 148, 1), more rarely simply club-shaped, as in Fig. 148, 4. The main breeding season is January-February. (Dr. Runnström's researches will be published in *Nyt Magazin for Naturvidenskaberne*, Oslo, 1927.)

Ad. p. 326. *PLAGIOBRISSEUS COSTAE*. This species has actually been found in the Atlantic. The author, having recently had the opportunity of examining the type-specimen of *Rhabdобрисsus Perrieri* Bernard from the "Talisman", finds it to be identical with the Mediterranean *Plagiobrissus Costae*. It was taken off Cape Bojador, 782 m.

Ad. p. 344. *POURTALESIA*. It appears that two more species of this genus occur in the deep sea of the N.E. Atlantic, there being in the material collected by the "Talisman" two fragments, one of which appears to be the true *Pourtalesia miranda*, the other a large species probably related to *P. carinata*. (Cf. the author's paper in *Bull. du Mus. d'Hist. Nat., Paris*, 1927.)

ILLUSTRATIONS

All those figures for which no source is given are original drawings or photos, made specially for this work.



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(This list is not intended to be complete, but only to contain the works of the more recent literature of special importance for the study of the British Echinoderms. Of the numerous works giving mainly fauna lists, only a few of the more important are included; likewise numerous small notes of a local character are omitted.)

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LIST OF ABBREVIATED AUTHORS' NAMES

Abildg.	Abildgaard.
Ag. or Agass.	Agassiz.
Asc.	Ascanius.
auct.	auctores (which means that most authors use this name).
A. H. Cl.	Austin H. Clark.
Blainv. or Blv.	Blainville.
Br. & Rob.	Brady and Robertson.
P. H. Carp.	P. H. Carpenter.
Dan. Kor.	Danielssen and Koren.
D. Ch.	Delle Chiaje.
Düb. Kor.	Düben and Koren.
de Frém.	de Fréminville.
Gmel.	Gmelin.
Gunn.	Gunnerus.
Hér.	Hérouard.
Herap.	Herapath.
Kef.	Keferstein.
Lamk. or Lmk.	Lamarck.
Linn.	Linnaeus.
Ljungm.	Ljungman.
Ltk.	Lütken.
Ludw.	Ludwig.
Lym.	Lyman.
v. Marenz.	v. Marenzeller.
Mont.	Montagu.
Mrtsn.	Mortensen.
Müll. & Trosch.	Müller and Troschel.
O. F. Müll. or O.F.M.	O. Fr. Müller.
Matsum.	Matsumoto.
Norm.	Norman.
Östergr.	Östergren.
Penn.	Pennant.
Perr.	Perrier.
Pourt.	Pourtales.
Thomps.	Thompson.
W. Th.	Wyville Thomson.
Verr.	Verrill.

With regard to the use of parentheses at the authors' names following the species names it may appear, at a first glance, to be very inconsistent. This is, however, only apparently so ; in reality the international nomenclatural rule is followed very consistently,

which says (Art. 23): "When a species is transferred to another than the original genus or the specific name is combined with any other generic name than that with which it was originally published, the name of the author of the specific name is retained in the notation but placed in parenthesis."

Thus, *e.g.* it is *Asterias rubens* Linn. or *Echinus esculentus* Linn., as these species still remain within the old genera *Asterias* or *Echinus*, to which they were referred by Linnæus. But it is *Solaster endeca* (Linn.), as this species is now referred to the genus *Solaster* instead of the genus *Asterias*, in which it was placed by Linnæus; it is *Ophiactis abyssicola* (M. Sars), this species having originally been referred to the genus *Amphiura* by M. Sars, who named it *Amphiura abyssicola*, while it is now referred to the genus *Ophiactis*—and so on.

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